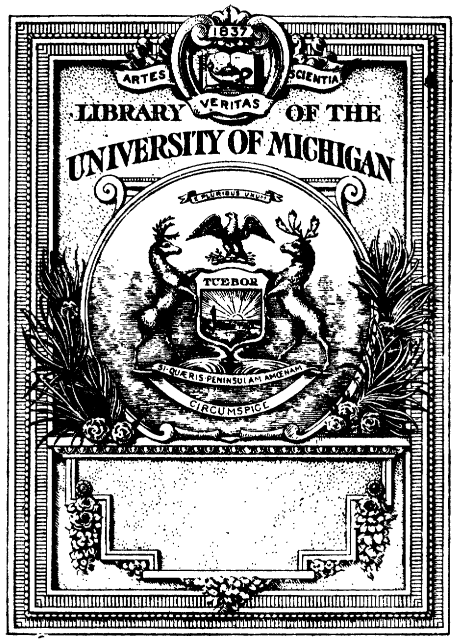
WYLD

PHYSICS AND PHILOSOPHY OF THE SENSES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THE

PHYSICS AND PHILOSOPHY OF THE SENSES.

THE

PHYSICS AND PHILOSOPHY OF THE SENSES;

OR,

THE MENTAL AND THE PHYSICAL IN THEIR MUTUAL RELATION.

BY

obert todart

R. S. WYLD, F.R.S.E.

WITH DIAGRAMS AND ENGRAVINGS.

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TO

SIR ALEXANDER GRANT, BART., LL.D.,

PRINCIPAL OF THE UNIVERSITY OF EDINBURGH.

THE AUTHOR OF THIS VOLUME
HAS PECULIAR PLEASURE IN DEDICATING IT TO
ONE WHO HAS GIVEN THE PUBLIC SUBSTANTIAL PROOF
OF HIS ATTACHMENT TO PHILOSOPHY, AND WITH WHOM YEARS AGO
HE ENJOYED DISCUSSIONS ON SOME OF THE TOPICS
WHICH ARE HERE AGAIN THE SUBJECTS
OF A MORE FORMAL CRITICISM.

PREFACE.

THE subject of animal life, and the connection between the mind and the external world, is one of the most interesting and mysterious which can occupy the attention of the curious.

Within the last twenty years, by the skilful employment of the microscope, the subject in its physical bearings has had a large amount of additional light thrown on it, and histology, by its numerous triumphs, has risen to the dignity of a new and highly important science.

Even within the last few years discoveries have been made which have materially affected the commonly received theory of vision, and have shown that our views regarding the functions of the principal parts of the organ of sight have been resting on a misconception.

These circumstances would alone be sufficient to justify an attempt to popularize the subject of the senses. But there are other more important considerations which have influenced the author in writing the present volume.

The author has had two distinct though closely allied objects in view. First, to supply a popular manual of the

senses, which, as regards the physics and physiology of the subject, might embrace the more important discoveries of recent times, and might thus be useful to the reading and inquiring portion of the community. Second, to present, for the consideration of competent and independent thinkers, a philosophical treatment of the subject, which, it is generally admitted, is far from having yet acquired that consistency and completeness which its importance has pre-eminently deserved.

In discussing the subject of life, organisation, sensation, and thought, the author, in opposition to the materialistic theory, has endeavoured to demonstrate that the senses, no less than our reason, furnish proof that an immaterial and spiritual element is the operative element in nature. The subject of power, force, or energy, its origin, its modes of working, and its transmission, has proved during the last thirty years one of the most interesting which science has handled, and it has yielded, perhaps, more solid fruits than any other branch of physical science.

Power, or force, being at once the cause and the measure of every physical change, we may regard it in this light, as affording us a key to the right apprehension of every branch of physical philosophy.

In Parts I. and VI. the author states his reasons for adopting a dynamical theory as the true foundation of philosophy; and in its proper place he shows that this theory has been held by men of the highest eminence in science and philosophy, and that it is becoming in our day more and more an article of well-founded scientific conjecture and belief. It is generally admitted that we have no knowledge of matter as an *entity*, or *thing in itself:* all we perceive in physical

phenomena are various manifestations of localized force. Philosophy, in such circumstances, has no choice—it must found on what it knows, and not on what it imagines.

The advantages of such a theory are, that while it allows the utmost freedom in the prosecution of physical inquiry, it at the same time satisfies philosophy. It furnishes an exhaustive theory of perception by removing the difficulties which since the days of Descartes have obstructed the progress of philosophic realism. Nor is it one of its least merits that it serves materially to elevate our conceptions of the dignity of the physical world, by leading us to regard it as a system specially designed and arranged for the benefit of sentient beings, and for regulating their intercourse with external nature.

More than twenty-two years ago the author, rather for his own amusement than with any serious object, published a volume entitled "The Philosophy of the Senses." The subject which he thus rashly undertook to handle was, at the time he entered upon it, one almost entirely new to him. As he proceeded, however, it opened out before him with its rich variety of facts, ideas, and speculations; especially when it came to be considered in its relation with mental phenomena, and with the multitude of curious metaphysical questions which these naturally suggested.

Since the period alluded to, the subject so lightly entered upon has continued to engross a considerable portion of the author's attention, and now, with leisure at his disposal, and with much more definite aims, he embodies in the present volume the results of more extended knowledge and reflection.

Except in its general arrangement, and in certain pages

of the chapters which treat of the physical laws of sound and light, and of taste and smell, this is an entirely new work.

For convenience, the author has divided the volume into six parts.

Part I. treats of Matter, Organisation, and Animal Life. Part II. treats of the Laws of Sound and Light, and the Organs of Sense. Part III. treats of the Special Senses, and of Touch, or General Sensibility. Part IV. treats of the Nervous System. Part V. is a Critical Sketch of certain leading Philosophical Works, Opinions, and Speculations. Part VI. is an attempt to explain and illustrate the Philosophy of the Senses.

EDINBURGH, *December*, 1874.

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ERRATA.

Page 5, line 4, *for* "respect that they are both" *read* "in as far as they are."
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PART I.

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CHAPTER I.

MATTER—ITS ATOMS—THEIR ENERGIES. POWER—OUR CONCEPTIONS OF IT.

THE animal alone is the subject of sensation, self-consciousness, and intelligence; but the philosophical treatment of THE SENSES involves a study, we may say, of all nature. It excludes no phenomenon, mental or physical, which, from possessing any distinctive character, may help to throw light on the subject. The physical world being the object of sense perception, forms thus a principal part of the problem to be examined, and the nature of matter becomes a first object of inquiry.

It is evidently important that the attempt be made to arrive at some more or less distinct conception regarding that substance of which all things visible and tangible consist, and even if it should be the case that we may not succeed in forming any perfectly clear conception of the true nature of this great basis of the physical world, it will, at least, be a point gained, if we help the reader to discover wherein the difficulty lies.

It will be admitted by all but idealists, who deny the existence of an external world, that the senses, and our active powers, reveal to us a vast variety of curious and instructive phenomena ; it is, therefore, reasonable to expect that, if we

examine these aright, some knowledge of a reliable kind will be reached.

Our examination, of course, must not be restricted to a mere noting of the forms and motions and colours of physical objects, as these are given by our passive sensations. We must look more closely than this, and, at the same time, with the utmost simplicity, in order that we may discover what are our real ideas of matter. If we are to obtain any light, it is evident it can only be by a faithful exercise both of our observing and of our reflecting faculties. If we have hitherto failed, or arrived at false conclusions, it is just as probable that this may have arisen from want of simplicity, as from lack of ability or effort.

Every variety of physical substance is described and recognised only by its qualities or properties; and if we reflect, we shall find that the possession of a quality or property implies the possession of some distinctive power, which enables the object to affect us, the observers, or to affect other bodies which may be brought within its influence.

Had the object no power of any kind, it is clear, humanly and rationally speaking, that it would be of no service in creation, and we could not even become conscious of its existence by the senses, or by any known means; for we know of the existence of physical bodies only by their having the power of affecting us.

The simplest inorganic mass, and the minutest particle of what is called matter, may be conceived, in this regard, in one or other of two ways; thus, either, first, we may regard it as possessing certain powers of action, peculiar to itself, and which originate necessarily from some property inherent in the particular substance, and which we may say is of its essence; or, otherwise, viewing the individual substance as a part or portion of a vast, skilfully-designed, and compacted physical system, we may regard each individual part as the mere instrumental cause of the action we observe it performing. In this latter case we regard the manifestation

of power as being exerted *only in connection with the different substances or objects*, while the *source of the power* remains unseen and unknown.

To both of these theories, in respect that they are both founded on the existence of an independent *entity*, called matter, we have insuperable objections on account of the inconsistencies which each of them entails; and this we shall endeavour to show. And we hope the reader will excuse us if in our remarks we necessarily become a little metaphysical.

Science has been unable to account for the existence of property or power in connection with any physical substance, or for the different properties of different substances.

It may be suggested by those who are in the habit of only regarding outward forms and appearances, that if chemists could ascertain the peculiarities which distinguish the elementary atoms of different known substances, they would then be enabled to explain the reason of their exhibiting their various distinctive qualities. Thus it may be supposed that there is something distinctive in the sizes, forms, or weights of the different atoms which determines their modes of action; or that there may be something in the position of their attracting and repelling poles. And this, so far as it goes, is likely enough, for form and rule and method are strictly observed in all physical arrangements. But such suggestions as these do not touch the difficulty, they do not account for the energy or power which we conceive to be in the substance.

Perhaps, however, the more general, loose, and popular notion regarding matter is, that elementary substances, having different properties, *must be essentially different substances.* This is a suggestion objectionable on every ground, and yet it is the prevailing theory. For purposes of convenience, we are taught that there are, at present, at least some sixty-five different known elementary bodies; and nearly every year is adding to their number. It may be necessary for the purpose of teaching chemical science, that we countenance this language;

but it is evidently intended to have reference only to outward manifestations, and not to interfere with the question of philosophy, which seeks to know the ultimate essence of things. It is, however, as we have said, philosophically objectionable: in the first place, because it multiplies *entities* beyond all rational bounds. While Spinosa, who so long pondered over the subject of *being*, could not bring himself to see the possibility of more than one substance, and that a spiritual one, to wit, the One Infinite Being, they who do not reflect are ready to accept fifty, sixty, seventy, or, if need be, a hundred essentially separate substances.

But, again, it is objectionable because the assertion that elementary bodies are essentially different entities is an assertion possessing no distinct meaning. When examined into, we find it impossible to bring any plain meaning out of it, except by giving first a description of the more external forms and colours of the bodies, and then of what marks their more important properties; as, for instance, their various amounts of solidity, tenacity, ductility, etc., and the various chemical relations which they affect. But these, and such as these descriptions, it is evident afford no insight into the essential nature of substances, seeing they have reference, as we have said, only to outward manifestations. In fact, in all such attempts we do nothing but describe in a circle, and never get an inch nearer the definition of the object we have in view. For instance, we explain one unknown body only by means of another equally unknown; thus, by solidity we mean no more than that one body resists the entrance of another body; by chemical affinity, that one unknown body acts so and so upon another unknown body. This is all our attempts at explanation enable us to say. The moment we attempt to define what we mean by substance, or essence, or elementary body, the mind finds itself fixed as in a metaphysical vice, which arrests all further thought and motion.

Seeing, then, we can form no conception of the nature of matter or of *ultimate being*, the next question, and one of

nearly equal importance, is this: Whence come those *powers of action* which we observe in physical bodies? How do physical bodies happen to possess a power of acting in this way, or in that way, or in any way implying energy? If we can answer this question to our own satisfaction, we gain an important point, for we settle to the satisfying of reason one of the chief questions of philosophy.

But can this question be answered? It seems to us that it not only can, but that it must be answered, for it is constantly before us, pressing for an answer; and though in answering it we are conscious that we are doing no more than forming an inferential judgment upon the data before us, and which falls short of what philosophers call a demonstration, yet this is clearly no reason for man sinking down into apathy and indifference, and professing an out-and-out philosophy of ignorance and scepticism. On the contrary, as moral beings, gifted with high faculties, we hold that man is called to repose with confidence upon the verdict of his mind, when it is honestly exercised on subjects such as these. Having a judging faculty given him, with full freedom to exercise it, we maintain he has good ground to trust this high and ruling faculty, when it is honestly and properly exercised. The human mind, be it observed, forms its conclusions not by chance or hap-hazard, but by rule. Its decisions are, therefore, not uncertain and variable. Like nature, its laws are fixed and immutable on all such subjects as lie properly within its province, and therefore is it that they who possess such a faculty are bound to repose trust in it.

If, indeed, man seeks knowledge beyond his range, he must expect to suffer disappointment. As, for instance, when he tries to define the nature of the *One Being*, or of any being, he must fail, for the human mind can form no conception of *being* in its abstract nature. But if we are satisfied to know that wisdom and power are exhibited in the world, and therefore that wisdom and power exist, and are the operative elements in nature, this seems to us to be a judgment which

lies quite within the natural bounds of man's faculties; for, far from experiencing any ineffectual straining of the mind to form such a conception, we find a difficulty in excluding it from the mind. There is no arrogance, therefore, in our forming conclusions on this subject; on the contrary, it presents itself to us as a necessity of our being to do so! Neither, if we keep the whole facts of the case before us, does there appear any possibility of a false judgment. No doubt the materialist proclaims *an eternal Cosmos;* but the more thoughtful mind replies, Yes; if this Cosmos possesses all the elements, moral and physical, which we see existing in the world and in our own minds, and especially *intelligence* and *power*, working ever forward to definite ends.

Starting, then, with the preliminary conviction of our incompetence to understand the nature of ultimate being or substance, but retaining a due estimate of the powers of reason within the legitimate field of observation and reflection, let us quit such considerations as have been occupying us, in order to make some such simple remarks on external nature as we cannot expect to be disputed by any one.

While there are a great variety of properties observable both in natural and in artificial substances, there are certain properties which seem common to them all, and without which we can not conceive a physical world to exist; such are, first, the occupying of space; then solidity, or the power of resisting compression; then tenacity, or the power of resisting the separation of their parts; then gravity and chemical affinity, both of which last are attracting forces; then *momentum*, or the power we discover to exist in moving bodies.

It is a very common and not very unnatural opinion, which many people form, that matter is inert. They do not deny that chemists are in the habit of exhibiting many dazzling experiments in their lecture rooms, which show the energy of matter. But their acids and alkalis and galvanic apparatus are not to be found ready made in nature. What

is seen on the surface of the earth seems to them entirely loose, inoperative, and inert—a mixture of clay and sand and lime and splinters of stone, and these ingredients seem dead and inert enough. We require to be reminded that these substances, inactive as they seem to be, have all in their day exhibited abundant energy and brilliancy; and that to reduce them to their present state has required an incalculable amount both of chemical and mechanical power. The clay, for instance, which is the most plastic of them all, when it was combined in its molecular state with silica, in felspar, basalt, and other volcanic rocks, maintained its connection with them so firmly that it required the mechanical action of millions of years to grind them asunder. But more than this, these aluminous particles, though they now seem to be so inert, are still exerting, individually, inconceivable power: each molecule, as we know, is a compound of oxygen and a bright metal, and these cling so strongly together, that chemical science has only recently learnt how to separate them. And the same may be said of the lime, silica, and other substances which constitute the covering of the earth. If by some unknown microscopic or other power the eye of sense, or the eye of reason, could examine any single particle of what lies under our feet, we would discover that it consisted not of dirt, a term opprobriously bestowed on it, but of millions of mysterious and imperishable orbs, bound together into patterns and systems so symmetrical that they would surprise us no less by the force that binds them together than by the geometrical precision of their relationships. A friend, on one occasion remarked to us, rather warmly, that he never could perceive any energy in matter. If it be so, we replied, take up that paving stone in your arms, and try whether it or you have most energy; or try to crumble it between your finger and thumb, and be convinced, once for all, of the extent of some of its powers.

Modern chemistry is founded on the doctrine of the atomic constitution of matter. This is an inference or theory de-

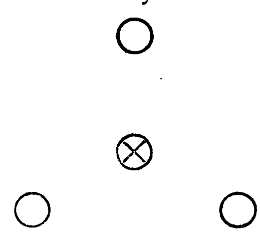
duced from the circumstance that substances, having mutual affinities, unite in definite proportions. Let us attend to the law, as illustrated by some of the best known and most important elements—oxygen, nitrogen, and carbon.

One atom of nitrogen in chemical connection with one atom of oxygen forms protoxide of nitrogen, or laughing gas. It may be represented thus,—

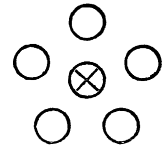
(where the atom of nitrogen is distinguished by a cross). We may remark that in the various gaseous compounds we mention, we shall represent the atoms as standing apart, because in aeriform bodies the constituent atoms must always be far apart. Were we, however, to preserve the true relative distances, the page would probably not contain the figure of a single molecule of any one of these gases, if the atoms were given on the scale we here represent.

One atom of nitrogen combined with two of oxygen forms binoxide of nitrogen, thus,—

This, as it escapes into the air, borrows immediately another atom of oxygen from the atmosphere, and becomes a ruddy-coloured gas of a very acid and suffocating character, known as nitrous acid, thus,—



One atom of nitrogen brought into relation with five of oxygen causes these strange atomic bodies to condense into a molecule of nitric acid, or *aqua fortis*, thus,—



In this last case the atoms are represented as brought much closer together, but not into

absolute contact; because neither in fluid nor in solid bodies is there ever absolute contact.

By bringing other two elementary bodies, viz. hydrogen and carbon, into connection with these same two atomic elements of which we have been speaking, we obtain a list of products so vast that it is impossible here to enumerate them, seeing such a list embraces nearly all that falls under the designation of animal and vegetable substance.

Now, one of the first remarks any one will make with reference to the physical constitution of the substances represented above, and with reference, therefore, to all other substances, whether solid, fluid, or aeriform, is that the *atoms*, if they be material atoms, *can never be strictly in a state of mutual combination.* If the materialist's theory holds good, the atoms in every instance must act *external to themselves*, and, as we shall immediately see, at some distance from each other; and it is in order to afford the reader a visible exhibition of this fact that we have given the representations of certain of these substances on the preceding page.

We have said that if the atoms are *material atoms*, we know that they must act on each other external to themselves; but we also possess evidence that *de facto* they *never come even into external contact.* Proof is afforded us of this in the fact that even the hardest bodies are subject to compression. Thus, the density, or specific gravity, of our common rocks are as given below,—

Granite has a specific gravity of	2·7
Basalt	3·0
Limestone and claystone	2·8
Sandstone	2·3

Now, the mean density of the earth, as has been ascertained by several astronomers, and by Cavendish, Mitchell, Baily, Dr. Maskelyne, and other competent parties, averages nearly 6·0. The earth has, therefore, more than double the specific gravity of the rocks on its surface; and, according to calculations based on this, and giving effect to the pressure to

which the rocks at the centre of the earth are subjected, we are brought to the conclusion that these rocks must be there condensed into one-fourth or one-fifth the size they occupy at the surface. It is calculated, however, that they should, at the centre of the earth, be condensed into one-eighth of their bulk, were it not that the law of compression is counteracted by the expansive force of the high temperature there maintained. If these calculations are correct, then it follows that the atoms which compose the solid rocks existing on the earth's surface, never approach one another nearer than two or three diameters of the supposed incompressible core. And it is equally clear that by no mechanical force which we can exert by pointed instruments or otherwise, can we come nearer them than this.

In considering the different combinations of nitrogen with oxygen which we have given above, it cannot fail to strike the reader as a singular circumstance, that atoms standing so far apart should act so powerfully on each other, and that minute changes in the relative proportions of the ingredients should be sufficient to make the different clusters, or molecules, appear to be substances with entirely different properties. If we, for argument's sake, assume the atoms to be material atoms, is it not evident that the mixtures can in no true sense be regarded as *compounds* of the elementary constituents? To apprehend correctly the nature of chemical action, even the believer in matter must regard it, not as the result of an incorporating and fusing of the different ingredients, but, seeing that the several atoms retain their integrity, and arrange themselves in definite positions, we must regard every new substance formed, not as a *compound*, but rather as a *system* in which the atoms are so arranged as to act dynamically on each other in specific manners, and, as we have said, external to each other.

It is right, in talking of these mysterious bodies, that we reflect for a moment on the inconceivable minuteness of each atom. Scientific men now assert that they are under the four

hundred millionth part of an inch in diameter. If the *action*, then, is admittedly dynamical, why, we ask, should we suppose the centre of each of these inconceivably small bodies to have a material core, say one-third the size of the circle of dynamical action of which we have cognizance? The idea is not only gratuitous, it is ridiculous.

If, again, the atoms were material atoms, would we not expect them to retain rigidly their individual properties. The conception of a material substance implies the possession of *fixed properties;* but, as we have seen, physical substances, though they retain their energies, entirely change their distinctive properties with every new combination or arrangement. The phenomena met with in prosecuting chemical science are indeed so marvellous and unexpected that they raise in the mind, even of the least speculative experimenters, doubts as to the atoms being material atoms. The most trifling difference in the proportions in which substances are combined, creates frequently an entire change in the property; witness the results of the various combinations of oxygen with carbon, with hydrogen, or with nitrogen; and witness the still more surprising animal and vegetable products which result from the united combination of these four simple elements—the oils, the gums, the dyes, the flesh, fish, medicines, poisons, and countless chemical principles which compose the catalogue of organic nature. If we view the atoms as matter, all is contradiction and confusion; if we view them as dynamical bodies, the phenomena are brought at once within the reach of our understanding, and we can form rational theories regarding their modes of acting.

The law of dynamical action is observed everywhere throughout the physical world. All objects act external to themselves. The relationship of the sun, moon, and earth strikingly exemplifies this law. The power of attraction between these large bodies, considered as a mechanical force, is enormous, and yet we know of no material connection existing between them to account for it. Here, then, as in

the case of chemical action, even if we adopt the materialistic theory, it is not matter which acts on matter, but an invisible, inexplicable, immaterial power, external to the masses, and external to the atoms, seems to rule their movements and affinities, and to draw them together with that extraordinary force which alike characterises chemical and planetary action.

To illustrate somewhat further the universality of this law of force, let us consider some of the most important operations of nature. First, then, all the work which has been performed on the earth's surface since the time that it was first compacted into an orb until now, has been achieved without the sacrifice of a single elementary atom; and how many heavy operations have been accomplished! The mountains have been upheaved; a notable quantity of the earth's crust has been ground down; strata after strata, several miles in thickness, have been deposited; Niagara and ten thousand other cataracts have ceaselessly poured their floods; and this, and much more than this, has been accomplished by the forces inherent in nature, or, at least, by a force some way or other in connection with nature; and the putting forth of this power, be it observed, has ever borne a mysterious relation with the movements and positions of these inscrutable physical atoms of which we have been talking. But what is most singular is that the atoms themselves, as we have remarked, in performing this work remain unaltered—"Such as Creation's dawn beheld them, they are now." Force, then, is a thing—or, let us rather say, force is an action, which has some mysterious relation with these atoms, but which is put forth without their nature or the integrity of their substance being in any respect impaired or altered.

In a later chapter we shall have an opportunity of observing more in detail the laws which regulate physical action. At present we merely view the fact in its simplest form, in order that we may be led to regard power or force in the light of an immaterial principle, or as the result of an immaterial principle connected in some way with the earth and

with its atoms ; and that we may clearly observe that through the ministration of this immaterial principle all physical and cosmical work is accomplished.

Then, again, in connection with the senses, let us observe that the same principle rules. Sound is the result of *mechanical force* transmitted from molecule to molecule of the atmosphere, till it reaches the organs of sense, and thence the percipient mind. Light is force transmitted through the substance of a more subtle medium, and which ultimately acts on the mind. Objects are visible to us because of the *power of repulsion* exerted between them and the atoms of this medium when in a state of vibration. In fact, the countless operations of nature are neither more nor less than various manifestations of this mysterious spiritual principle which we call power.

But here we are called on to answer a question, and a very pertinent one. If we do not know matter, but only certain phenomena, which, when examined into in their relation to the senses and to reason, yield us nothing but certain perceptions and conceptions of localised power or force, what do we mean when we speak of force and power? And again, another question is this: Are we conscious of power? These questions have given rise to infinite discussion. It has been denied that we have any consciousness of power; and it has been considered a matter of extreme difficulty to explain how we come to have any belief in power, or any idea of it whatever. We shall not enter upon this discussion here, we shall merely state our own conception of the matter, and of the light in which we regard it.

We mean then by power, in the first place, the *ability to do anything*. I am conscious of the power of thought, and I am conscious of the will and of the effort to move my body. Let us pay some little attention to this subject. It requires a certain amount of mental effort to solve an intellectual problem. I have to keep before my mind the various branches of the subject, and to consider and weigh their

import, and thus, from experience, if it be a practical question, or by an exercise of reason, if it be a logical point, I am enabled to arrive at a conclusion.

In the same way it requires a certain measured amount of felt mental effort to move the limbs and obtain an external physical result. In performing a piece of music on the piano, certain passages are marked to be played *piano*, and other passages *forte;* and this the mind causes the fingers to perform faithfully, easily, and gracefully, so that the exact amount of force is employed to produce the desired result. In the same way, in lifting heavy weights, we are conscious of mental efforts, commensurate with the amount of work to be executed. Before moving a very heavy weight the mind dwells gravely, it may almost be said solemnly, on the task it is about to perform; the face shows anxiety and determination; and at length, when the state of inward preparation is completed, the will and the active energies of the mind are exerted, and the physical feat is accomplished in accordance with the will, through the medium of the bodily organs.

In all these performances, whether of pure thought, or of will, directed to physical action, we are conscious, as we have said, of mental effort and this word effort, necessarily implies the exercise of power: to say we are conscious of mental effort is the same as to say we are conscious of the exercise of mental power. If the mind is distracted or disordered we may not be able to exert the mental effort necessary to solve a problem; or if the body is impaired by disease, or exhausted by fatigue, we may not be able to execute the piece of physical work; and why is this? Because the exercise of the limbs in voluntary motion is the result of the working of the mind in connection with the physical organs—the brain, the nerves, and the muscles. If any one of these links in the chain is impaired the attempt fails; thus, if the mind lacks energy, we may *will* to move the arm, but the arm does not move, or moves languidly. We are

conscious of the act of will, but not of the due mental effort which accompanies and causes all sustained physical action. When the nerves of the arm are paralysed, we may wish to employ it in raising a weight; and we may be conscious of the act of will and of the possession of mental vigour, but we are not conscious of any sustained mental effort. Any endeavour to sustain a mental effort in such circumstances is felt to be extremely distressing, and we shrink from exerting it. What is the effect on the brain of an effort such as a paralysed person may exert we do not know; but the attempt being distressing, as we have said, is instantly discontinued; such an attempt is like a mocking of one's self, or a probing of one's own wound, and we instinctively recoil from it.

Under healthy voluntary action on the other hand, we are conscious of the mental effort, and we are conscious, also, of the muscular sensations which result from it. The latter we rightly interpret as an indication of the amount of muscular tension existing in the limb; and the mental effort we regard as the originating cause of the muscular action. And as it is not only a physical law, but also an axiom of reason in connection with physics, that action and reaction are equal; so we measure the amount of the external resistance by the amount of mental effort of which we are conscious. We may remark here, in passing, that we are not to imagine that the mind thus gets any perception of the absolute amount of external resistance. No; our knowledge of external resistance is merely relative, and we estimate it by the amount of mental effort we are conscious of exerting.

Neither are we to suppose that the *muscular sensations* give us any direct knowledge of physical resistance. Of themselves these contain nothing to indicate action or power of any kind, and they would remain for ever without any such meaning, were it not that the consciousness of will and mental effort teaches us of internal power exerted, and, consequently, of external resistance in the objects moved; and as these muscular sensations accompany all mental effort of this

kind, and are proportioned to it in intensity, they thus become, as we have said, most useful symbols or indexes of the amount of physical force exerted and resisted.

This is nearly all we can say of our knowledge of power —that it is the necessary result of our consciousness of mental energy and effort, in whatever ways exerted, and that our exercise of it constitutes the chief element in the life of every active human being, and of every living energizing animal.

One word more regarding power. As power is a supremely important possession, so is its nature also supremely mysterious. We cannot describe it; we can only name it, and speak of its doings. As for instance, that it enables us to think and to act. It is thus peculiarly regarded as the principle of activity within us; but in itself, what is it? and how have we got this power of thinking and acting? What is the secret of this faculty which the mind possesses? This we cannot tell. We can only say or suppose that power is the inherent and essential property of what we call mind. It is the action of the mind—of *a* mind finite and of *the* mind infinite.

From this inability to fathom the secrets of our being, and of all or any being, the philosopher has the conviction forced on him that all that exists in this world in which he lives rests upon the unfathomable, the unknown, the unthinkable, and upon powers and causes which we may surmise to exist, but which we can neither discover nor define.

But, though the unseen cause of all things may in its nature be unthinkable, yet something of its character we may, and we do, presume to predicate; for as the intelligent principle within us believes in power by being itself the conscious possessor of it, so, in our philosophical inquiries, we find it not only natural, but, we may say, necessary, to associate intelligence with power. This finding of finite power associated in our own being with finite intelligence, seems sufficiently to account for our conceiving Infinite Wisdom and

Infinite Power to exist in necessary and eternal union. And this conviction is doubtless strengthened within us by our finding so many constant indications, not only of power, but of wisdom, spread around us in the economy of nature. It constitutes man's highest happiness when he can rest satisfied on such a conviction as this; and to do so is certainly the most valuable fruit which practical reason permits us to enjoy in this world.

We do not say it is necessary to cease from all further inquiry regarding the nature of matter, or of mind, or of power. Such metaphysical investigations, though they must be futile in their direct object, yet yield much reflex benefit to thinking men. They bring us into a more intimate recognition of the mystery of our being, and they raise us above the hard, narrow, and debasing doctrines of materialism.

A sober and rational philosophy, then, casting aside all expectations of demonstration from transcendental thought, is content to rest upon what it knows, and to restrict its aims to those all-important but humble efforts at deduction which it considers reason entitled to make.

The great object of philosophy is to obtain possession of *one fact;* for, having this, we may possibly either connect other facts with it, or we may, at least, from it form far-stretching but reliable deductions.

Leaving metaphysicians and transcendentalists, then, to cavil, we assert that the great one fact to man, and to every living creature, is this, *I am.* This fact embraces within it, as a mere expansion, this further truth: I am the conscious possessor of certain high and mysterious faculties. This is all man knows of *his being.*

The belief, however, that we are conscious, energizing agents, draws certain important deductions after it. Thus, for instance, these faculties of conscious being which I possess are not self-caused—they must be derived from *a competent source.*

Another deduction is this: I am not the only self-conscious

being, I am a ~~link~~ in the mighty ocean of being which is spread around me, I am a part of it—connected in some way with it. My intelligence is in some way derived from, or connected with, an external source; it comes not certainly from insensible, unintelligent matter, but from an all-pervading intelligence, connected somehow with the world and with all that is in it, physical and mental.

This is a necessary deduction, in respect that it is, of all things, the most irrational and the most difficult to believe either that I am the underived possessor of intelligence, or that my intelligence springs from an unintelligent cause. It is thus that I am compelled to believe that, in necessary connection with me and with the world, there exists a great, all-pervading intelligence.

Beyond this, into any of the antinomies which reason encounters when unwarrantably dealing with *infinity*, we venture not. We are content to rest upon the one great law or instinct of our rational and moral nature just alluded to. In endeavouring to do this, and to follow out the most curious of all subjects, that of the senses, we confess we shall naturally be anxious to settle this question: Whether or no, in the laws which regulate the connection between the mind and the physical world, there can be discovered any special evidences of the operation of intelligent immaterial power?

We may, perhaps, be here interrupted, and asked, Is the position we are tending to not equivalent to pantheism? If the physical world is to be regarded as no other than a manifestation of infinite power, reducing itself to finitude and law, and if we are to regard the mind as derived from the same source, is not this a merging of the ALL in the ONE? We reply, that to all who adopt a philosophy of realism, and are content to accept the teaching of the senses as interpreted by reason, the theory proposed leads to no such conclusion.

That the physical world is a part of a measureless ocean of being, this we believe; but that living, self-conscious beings are but sparkles of localised consciousness occurring

in it, and rippling, as it were, its otherwise motionless surface or substance, this is pantheism, and this, even if we were willing, we could not accept. Pantheism gives a constant lie to our strongest convictions as living beings, the conviction of the individuality, the self-will, self-agency, and responsibility of the mind; and, what is equally objectionable, it represents the Omnipotent as directly responsible for all the blundering and inconsequential thoughts, and all the foolish doings and delinquencies of His creatures, and therefore we reject it.

We would be glad to be informed on what ground of philosophical necessity, man, who knows nothing of the true nature of being, should presume to declare that a state of finite but independent mental existence is impossible. To the writer it appears much more consistent, in our confessed ignorance of being, to give full effect to the dictates of our consciousness, and to hold the popular belief to be the philosophical one; namely, that we and all self-conscious beings are endowed, as regards the mental principle, with the exercise of independent powers.

Difficult as it may be for the finite mind to realize the idea, yet it is undoubtedly the idea or theory which is in every respect the most agreeable to reason, that there is but one essentially infinite uncreated, or necessarily-existing being. But believing this, we can see nothing illogical and contradictory in the belief that this Being, out of His own infinite essence, should have formed beings with faculties to act separate and distinct from Himself, and have gifted them with a portion of His attributes of intelligence and power, so measured and adjusted, however, as to subserve the special purposes of their being.

A few more words to explain what we mean when we talk of force or power. When we talk of force in connection with physics, we use the term which is most expressive of the phenomena of which we are conscious in our dealings with the world. We have shown that the consciousness of mental effort accompanies all such dealings, and that this

effort or exercise of mental power is employed in causing the limbs to operate on external objects. We admit, as we have already said, that we cannot analyse or explain our ideas of the nature of power; we can neither tell *how* the mind possesses so high a function, nor *how* such a thing as power exists in the world, nor *how* it operates. But our ignorance of this mystery affords no reason for our rejecting the use of the term, for were we to be so hyper-critical as only to use terms whose full import we understood, our lips would be for ever sealed from employing that part of speech called a *noun*, or name; for in an ultimate or transcendental sense we know no one thing that exists. Subject to this explanation we hold the use of the term *power* perfectly correct and suitable for indicating the apprehensions we have of it, and we shall in this light employ it.

If we have, then, with any distinctness explained the properties of the physical world as these are perceived by us, the reader will be prepared at once to join with us when we proclaim the visible creation to be a magnificent system of complex dynamics, graduated and governed so as to evolve the various phenomena observed in our ever-moving and advancing world.

And the reader is called to observe, moreover, how important are the consequences which flow from such a theory. We shall see that, among other things, it involves this conclusion: That the intercourse of man with the physical world is the intercourse of force with force, of mind with mind, of the finite with the infinite. For if we conceive the world as a system sustained by infinite power, and as exhibiting proofs of plan or purpose, this is equivalent to regarding it as an exhibition of the ever-present acting energy of the Supreme Being, and as being maintained for special purposes. And if the mind is to go further, we must conclude that the world being not a *thing*, as the materialist conceives it, but a system working out the will of the

designer, so, when the purposes of that *infinite will* are accomplished by it, this complex play of physical power—this intricate antagonism of balanced forces which we call the world—shall be willed out of existence, and shall *eo ipso* vanish as a thing that has never been.

How miserable a philosophy is it which conceives this majestic system to be ruled and governed by an insensible substance, such as the common and, if we do not say gross, we will at least say unenlightened, imagination of the unthinking depicts matter to be. No doubt most persons insist that though matter is the chief thing in the physical world, yet it is Deity who conducts the laws of nature and sustains the powers in matter. Observe, however, how contradictory such a theory becomes when we examine it; for if the support of Deity is required to account for the action of matter, is not this an acknowledgment that matter possesses no power of its own? And if it possesses no powers, then it can be of no service in creation, and in fact cannot be conceived to exist; for the essence as well as the use of *being* is, as we conceive it, to possess certain powers.

We have here stated some of the considerations which induce us to adopt views adverse to the prevailing materialistic theory of the world. If the reader, however, can work out a consistent theory of his own; or if he, after dealing fairly with all the difficulties, is satisfied that the world and its various phenomena, organic and inorganic, can be explained by the assumption of material atoms, we leave him with his opinions. But if, on fuller reflection, materialism should prove unsatisfying to him, the theory of power emanating from a one intelligent Cause may perhaps then gain his more favourable consideration. Let it, however, be clearly understood that the author has no desire either to discard the external world from his belief, or to discard the word matter from his vocabulary. All he wishes is to correct the false and puerile interpretation which is usually put on the word. The pavement on which the writer

walks is as solid and real to him as to any man, but on good grounds he holds its constituent atoms—those inconceivably minute bodies whose energies can rest on Omnipotence alone —to be dynamical and not material bodies, *i.e.*, not entities self-existent, self-acting, indestructible, independent.

Another observation we must make in concluding this chapter; namely, that the difference in our respective views as to the source and origin of power will not interfere with our studying and, if possible, exhausting the subject of the senses so far as it is a branch of physics; for a dynamical theory does not interfere with a single fact of physical science. It is a satisfaction to the writer to know that such a theory has been favoured by many leaders in science. We need only mention Newton, Leslie, Faraday, Herbert Spencer, Huxley, and others. It is equally evident that Dugald Stewart viewed Boscovich's theory with a curious interest, though he never attempted to work out the problem, nor did he fully see its philosophical importance. Hamilton's arguments on the nature of our conception of the creation of the world also lead inevitably to dynamical conclusions when followed out. And, lastly, we may mention the name of James Hutton, the father of modern geological science; he wrote three quarto volumes on the subject, but his views seem rather to fall in with those of Kant than with that substantial realism which the writer here supports. The *Investigation of the Principles of Knowledge* was published in Edinburgh in 1794, and the *Critique of Pure Reason* appeared in 1781; but whether the Scottish geologist had read the German work, and, being smitten by the logic of the sage of Königsberg, was led to adopt transcendental and idealistic opinions, we do not presume to determine.

CHAPTER II.

ORGANIC NATURE.

In the preceding chapter we considered the atomic constitution of physical bodies. We noted the circumstance of the atoms possessing properties—in other words, energies or powers. And we noted that this energy manifested itself in various ways. Thus, first, that it caused certain atoms to connect themselves in balanced groups, or fellowships, with other atoms. We noted, also, that to our senses each of these clusters or fellowships appears as a different substance, that is to say, a substance possessing new ways of affecting us and other bodies. We observed, also, that in these clusters the atoms act on each other external to themselves, and therefore dynamically, resembling in this respect the large bodies of space—the sun, earth, moon, and planetary bodies generally. We also observed that when these atoms are so combined into masses as to become objects of sense, we are, strictly speaking, not conscious of the atoms being material atoms, nor of the masses being material masses, but are only conscious of the *localised resisting powers* which each part and portion of these clusters or masses exhibit.

We have seen, further, that it is the mind or, to employ the widest designation we can find, the conscious, intelligent principle, that perceives these energies, or attracting and resisting powers, in atomic bodies. It does so by the consciousness it possesses of *its own active power*, and of this being opposed by external bodies; that is to say, we are conscious of the power exerted by the mind over the limbs being either thwarted and overpowered by external

resistance, or else of our succeeding in overpowering that resistance by the exercise of measures and degrees of mental effort suited to the necessities of the case. There can be no doubt that it is in this way that we acquire our knowledge of the primary properties of external objects, viz. by the consciousness of our own powers. This being the case, our perceptions of the external world, as a solid physical world, may be explained as the consciousness of a conflict of mental power with external power. And as, according to human apprehension, *power* is not matter, or substance, or *a thing*, in the ordinary sense of the term, but rather *an action* of a spiritual and immaterial character, so we are—without any straining of the subject, but by necessary and inevitable steps—brought to the conclusion that our perception of the world is, *de facto*, an intercourse of power with power, of spirit with spirit, of the finite and limited principle which we call mind, with the Infinite Mind whom we hold to have called us and the physical world into existence.

In the preceding chapter we have stated that the atoms, when combined in a certain way, constitute what we call inorganic substances. When they are combined in another way they constitute the substance of vegetable and animal organisms. It is the province of the chemist to ascertain in what manner these atoms are arranged in the different substances found in nature. There is a distinction in the nature of the arrangement in inorganic and in organic bodies of a very marked character, but this is so well known that we need not here dwell upon it. Suffice it to say, that it is by virtue of the peculiar nature of its chemical constitution that the material which constitutes the substance of living organisms is at all fitted for the purposes of animal and vegetable life and growth.

The animal is to be the special object of our study in this volume; but as all knowledge is obtained by contrast, and is, indeed, correlative, seeing that all nature hangs as if by a chain, so, if we seek to understand any one phenomenon, it

is necessary to enlarge our range greatly beyond the limits of the object we specially desire to study. We may, perhaps, by-and-by allude to some important scientific distinctions existing in the constitution of organic and inorganic objects. We shall, however, at present merely direct our attention to certain broad and well-observed principles which distinguish the members of organic nature, and which mark an energy to be at work within them which we do not observe in the mineral kingdom. First, then, while the parts of the mineral are all independent, homogeneous, and separable, it is not so with the plant or animal; on the contrary, the *different parts* there combine to form *an organic whole*—the *many* essentially form the ONE—the individual plant or the individual animal. This is the first upward step we observe; and how much mystery is involved in it! If we could explain this we might safely say we had found the key to all philosophy and to all knowledge.

When a stone falls to the ground we cannot tell the reason why it takes this direction, or why it moves at all, because we are unable to demonstrate the source of power, and till we can do so the laws of nature are to us as sentences written in an unknown tongue. The mystery, however, becomes still more interesting and more surprising when we contemplate the laws of nature as exhibited in the formation of organic beings. When I see a man take a mass of dry clay, moisten it with water, and, after he has reduced it to a plastic state, fashion it into the head of an Apollo or of a Jove, I can say that, to a certain extent, I understand the process. Though I may not understand the source of the powers or properties which belong to the water and the clay, yet, having a knowledge of the simple elements of physical science, I comprehend so far the steps of the process; thus, first, I understand how the water enters the pores of the clay, separates its parts, and makes it plastic; again, I understand that it is by physical force applied in moderate degree that the artist moulds the clay into the forms alluded to; and,

thirdly, I know that it is mind, or intelligence, that guides the force by which this last and crowning part of the process is accomplished.

Suppose, however, that a mass of clay had been rendered soft and plastic, and that on returning to my studio after a period of absence, I found that the amorphous lump had assumed the form of one or other of those models of grace and majesty of which we have spoken; what, we ask, would our reflections on a circumstance of this kind be? Should we not be justified in saying that an unseen power had been at work; and, moreover, that this power, whose nature and mode of operating we had not witnessed, must at least have possessed intelligence, taste, and skill? Such seems to the author very much the position in which we find ourselves when we contemplate the possibility, probability, or certainty of organised beings, vegetable or animal, originating by what is called spontaneous generation in vegetable infusions. Suppose this much disputed theory established beyond all cavil; suppose the proper infusions are prepared and effectually protected from the atmosphere and from all possible importation of living germs, and that I leave them alone for a time, even as I left the prepared clay, and that, on my return, I find the fluid swarming with life; how am I to explain the phenomenon? I ask, Am I justified in declaring the unconscious matter to be the parent and creator of the various creatures which are disporting in it? This is the theory of not a few scientific men of note in our day; and we do not wonder that the theory, viewed in this light, should excite the aversion of all pious but credulous and unphilosophical persons, as affording a powerful stand-point to atheism. To us, on the contrary, the theory, if it can be established as a fact, is eminently interesting, because it exhibits to all reflecting minds the strongest conceivable evidence of a Divine power working, though unseen, among us in the world. But then, instead of regarding the hay-juice or turnip-juice as the sufficient cause of the phenomenon, I conceive it to be

merely the prepared material out of which the living organisms are made. What does turnip-juice know of sensation, life, limb, and organic structure? The man of science may be a very skilful microscopist, but there must be some defect in his mental powers if he can satisfy himself that his microscope has discovered the cause of these mysterious phenomena. The softened clay was the suitable material out of which to mould a work of art, and the vegetable infusion was the material out of which alone the infusorial creatures could be framed. But a power unseen, unknown, but competent to the formation of organic life, is even more urgently required to explain what must be held to be the greater marvel of the two; for we must ever consider the formation of creatures, endowed with organs, and with instincts conform, a much higher act of creative power than the mere moulding of a particular form, however majestic, out of a prepared mass of shapeless clay.

It will be seen we are not here objecting to the doctrine of spontaneous generation; on the contrary, we do not see how we can escape the conclusion that all the humblest infusorial and other animals, and all the lowest forms of the vegetable kingdom, must originally either have been made out of nothing, which is an unnecessary and gratuitous supposition, or out of the elements previously existing. The only question of importance seems to be, not out of what material these primordial organisms are formed, but, what is the power which forms them and endows them with their powers and instincts. There is, it is certain, nothing which the chemist or the natural philosopher knows to exist in the nature and constitution of matter which can explain this.

We return from this digression with the view to observe another proof of this constant, upward, onward, outward, or diffusive tendency in all that pertains to life, and in order to exhibit the energy which rules there, as in contrast with the principle observed in inorganic nature. Inorganic objects, however firmly they may be compacted together, all naturally

tend to disintegration, decay, and decomposition. All inorganic action takes a downward direction, and by the mere following out the law we find it is destined sooner or later to bring the world and all that it inherits to a final stop. The energies exhibited in inorganic nature—both those exerted on the surface of the earth, and those which rule the vast bodies of space—however powerful and majestic their movements may be, and however ingenious and beautiful their arrangements may appear, yet all of them when examined are found to be working towards this consummation; the movements of most of them is in fact a race, more or less accelerated, or more or less retarded, to a bourne whence, through none of the energies presently at work in nature, is there any discoverable means of return. "Surely the mountain falling cometh to nought, and the rock is removed out of his place."

Everything in inorganic nature tells us of a beginning, a middle, and an end; not a temporary end, but, so far as appears, a final and conclusive winding-up of the entire physical system. The rill rising high up on the mountain side, and playfully leaping from rock to rock, then sweeping through glades and murmuring through rapids, at length inevitably reaches the dead sea level. No doubt a power will again raise the waters to the clouds, to be again poured down upon the earth; but this is only another turn of the wheel which is levelling the mountains, and strewing them along the sea bottom. A centralizing principle, unless a supreme power reverses the law, exists everywhere, which will at last bring mountain ranges, suns, and planets into one common centre, where all organic and inorganic motion and life must necessarily cease.

But while this is the direction of inorganic nature—to fall ever to lower levels—a different principle is seemingly at work in organic nature, whose ultimate end, however many checks may be encountered in the execution, is ever, so long as it lasts, one of expansion and progress. This, however, is not at once apparent. For, first, it would seem as if the

subjects of this division of nature were rather destined to destruction; for in contrast with inorganic bodies we cannot fail to be struck by the tenderness and frailty of the substance of all organized beings. Individually they are exceedingly easily destroyed; and when seriously injured, or stinted in their nutriment, the spring seems snapped, and their substance tends to quick resolution into its original elements. Moreover, if we inquire, we shall find that every portion of the substance of living beings is the scene of never-ceasing disintegration. What then, we may inquire, prevents the speedy destruction and removal of every trace of organic life from the face of the earth? It is the ceaseless energy, this principle of which we speak—this ever-working power to which, in absence of a better name, we apply the descriptive designation of life, or vital power. Through its action a process of reconstruction as well as of destruction is steadily maintained, and in this seeming contest the reconstructive element prevails. The individuals indeed perish—this is their destiny;—but while their strength is at its highest, they transmit a recast of themselves to future time—instead of the fathers, come up the children; and thus, as we have said, though the individual links are worn out and perish, the stock stands its ground; and we have every reason to believe that at the present day the organic world, in all its branches and ramifications, is stronger, surer, and greatly more advanced than it was many thousand centuries ago.

Geology shows this expansive energy to have operated from the first appearance of life upon our planet until now. This science has done more to enlarge and revolutionise our beliefs than any other physical science. The strain, however, which it sometimes puts upon us is felt to be very great; and to many minds it has proved infinitely more painful than pleasant. If geology has not originated, it has at least brought with startling suddenness before us, what we may almost call a new theory of creation, which professes to be founded on the surest of all evidence—the exhumed records as written,

chronologically arranged, and sealed up in the keeping of the the earth's own bosom; and so striking are the details, that it can scarcely be doubted that the theory of the evolution of living beings, subject no doubt to various important explanations and modifications, is destined to take its place as a scientific, philosophical, and religious form of belief. By not a few it is already so regarded, while many more have been brought to view it as a possible or even as a probable theory. We are not prepared to surmise what form this theory may ultimately assume. One fact, however, is already established; namely, that the process of furnishing the earth with living creatures has been a process of steady and unvarying progress. One idea, one aim is apparent, and that is expansion —upward growth, increased complexity from age to age, increased physical capacity, increased intelligence.

How different, so far as we can see, might the earth's history have been. Might it not have been a standstill? What do we discover in mineral nature that could lead us to anticipate the rise out of it of life and activity and enjoyment? Or suppose life to have manifested itself in various obscure organisms, what could have led any observer of these despised creatures to predict the appearance of greatly higher and richer varieties of life? Instead of such an expectation, would we not rather have had grounds to anticipate the gradual obliteration and removal of the frail beings from the earth, subjected as they were to the heats and colds, and thousand adverse influences encountered in the world. But instead of this downward and backward movement, we witness with delight and wonder the appearing and constant branching out of the higher and higher types of life, until every nook of the dead mineral earth has become adorned with plants and flowers of endless variety of structure and colour, and has become peopled with sentient creatures endowed with the most wonderful diversity of organs, instincts, and habits of life.

This upward direction of nature's forces speaks differently,

it would seem, to different minds. To us it speaks clearly of plan and purpose; and it gives us the assurance that mind, or intelligence, has presided over all the arrangements. We do not deny that it might have afforded us a more lively and immediate gratification had geology furnished a literal confirmation of our educational beliefs, unfolding to us the magnificent spectacle of animal and vegetable creation as the fruit of a six days' creative energy. But, were it not for our educational habits of thought, would this have truly afforded us more glorious proof of creative power? However this question may be answered, one thing is certain the exhibition of a six days' work was not nature's plan, and truth must ever be held infinitely more precious than any belief, however pleasing it may be to us, or may have been to the imagination of the world in an infant stage of mental development.

The chief suffering inflicted by new theories, and, we may add, the chief danger, falls upon us whose lot is cast in these transition times; for when new truth marches in to tread down old tradition, it comes ever in its harshest and crudest colours, unmellowed by the religious tone which the genius and piety of past ages have transfused into the old belief, and we recoil from it as from a thing both bitter and conceived to be debasing.

Finding that all free and candid consideration of such subjects is banished from the pulpit by a religious teaching which stands stereotyped in articles framed centuries ago, what is a thoughtful man to do? He feels that he has no alternative but humbly for himself, and perhaps within the silence of his own bosom, to construct what must, so far, be called a new theology. What man of educated mind does not feel in the present day that there is but one alternative; and that he must either submit to simple shipwreck of his educational faith, or else must learn vastly to extend his conceptions, and realise almost, as it were, for the first time, how far the Infinite Being, in His nature and method of working

has transcended all that our feeble powers have hitherto pictured and imagined. There can be no doubt that it requires the most generous expansion of our nature to do this aright, and the fullest exercise of the deductive and generalising faculties; but the battle has to be fought, and there is no use in shrinking from the encounter. And here let us remark, that though science, with its keen but narrow vision, has frequently shown no strong sympathy with many questions which must be held to be of the highest importance to humanity, and, in dealing with physical details, has often overlooked the moral and intellectual elements of our nature, and so has come to insufficient and unsatisfying conclusions, yet we are very far from hopeless on this account.

Science, we believe, is destined, like all that deals with truth, to contribute largely to the progress both of philosophy and religion. The facts of science must, however, not be hastily and hurriedly interpreted ; philosophy must apply itself to them, and this much more seriously than it has yet done. We are endeavouring to commence this examination in some of its simplest forms, but we look for abler minds to follow up the attempt. If it shall be distinctly seen and admitted both by philosophers and men of science, that neither the senses, nor any of the other faculties of the mind, inform us of the existence of matter, but merely of the existence of power, and that the physical world thus becomes a manifestation of spiritual and not of material action, we shall then be brought to consider all earthly phenomena under an entirely new light. We shall see that on the earth's surface, under the operation of this power, have been evolved beings endowed with self-consciousness and thought ; and, moreover, that the world has been fitted up, as the study of the senses informs us, with the most curious and complex contrivances, which act specially in ministering to the intellectual wants of these creatures, in their intercourse with nature. And it will thus become a question equally important and imperative for us to decide, whether the power

which produces all this is a blind power, or is a power distinguished by intelligence.

We need scarcely warn the reader not to misinterpret our language, and suppose that we regard the *world* as the Creator. The world can only be properly regarded as a visible and finite, and therefore partial, manifestation of that *one power* which is invisible and infinite.

CHAPTER III.

ANIMAL LIFE AND ENDOWMENT.

IN the preceding chapter we have alluded to an active energy which is exhibited working in the animal and vegetable creation, and not only sustaining the feeble links from destruction, but also causing living organisms to bud forth into new and improved forms. This energizing principle, as we stated, distinguishes itself also by the mode in which the elementary atoms are made to combine and group themselves in forming organic structures. The consideration of these peculiarities leads us now to inquire: Is there anything discoverable in the constitution of animal or vegetable substance which may account for these peculiar activities of which we speak? We say at once and distinctly, there is not. The phenomenon of the growth of successive generations of animal and vegetable organisms, and the phenomenon of sensation or consciousness, science cannot account for, nor in any measure explain. It cannot show that these are the result of any known chemical or physical laws. We may, we think, confidently declare that the attempt to explain by physical causes even the simplest of vital phenomena, namely, the cause of organic structure, will ever be beyond our power; while consciousness and thought are phenomena so mysterious, that the attempt to find their solution within the field of physical science will of all attempts prove the most Utopian and unpromising. Science has, indeed, made many important discoveries concerning the chemical changes which occur in the living organism during the operations of digestion, assimilation, and secretion, but

regarding what it is that acts as a formative power, and out of cellular and molecular substances produces internal and external organs, science suggests no clue. Though such is the case, there is no necessity that a precise science like physics should cover its defeat by setting us on a false track, but this it sometimes does.

It seems to us that some writers have treated the subject as if it were one of no special difficulty, and as if all that were necessary for an enlightened comprehension of it, were the removal of certain educational superstitions from the public mind.

Many of the facts which embryologists, physiologists, and chemists lay before us are in the highest degree interesting and important; but we never feel that the deductions to be made from these can safely be left in the hands of these men of science. In introducing some thoughts on the subject of vital phenomena, we shall, perhaps, best gain our object by quoting from a public lecture on the subject, delivered some few years ago, and which from its having become more extensively read than probably any other writing on the subject, may prove all the better medium for leading us over the ground. We shall give its arguments in the order in which they occur, though in an abridged form. It will be seen that the author of this discourse first assumes the character of a defender of materialism; but before he closes the exposition he leaves us in a state of unsatisfied surprise by disclaiming all belief both in matter and in spirit. This avowal of unbelief will afford us an opportunity of making a few reflections on some other aspects of modern thought.

Professor Huxley, in his famous lecture on "Protoplasm the Physical Basis of Life,"[1] says:—

"There is a single basis of life underlying all the diversities of vital existence. There is a threefold unity, namely, a unity of power, or faculty; a unity of form; and a unity

[1] Delivered in Edinburgh in 1868, and afterwards published in the *Fortnightly Review*, 1 February, 1869.

of substantial composition, which pervades the whole living world. Protoplasm, simple or nucleated, is the formal basis of all life. All living powers are cognate; and all living forms are fundamentally of one character. The researches of the chemist have revealed a no less striking uniformity of material composition in living matter. One fact is this, that all the forms of protoplasm contain the four elements, carbon, hydrogen, oxygen, and nitrogen, in very complex union."

This statement may be admitted to be substantially true; but the application which Mr. Huxley makes of it to the solution of the great biological problem, so far from having consistency or strength, seems to us to stand in the attitude of a palpable *non sequitur*.

"When hydrogen and oxygen are mixed in a certain proportion," says he, "and an electric spark is passed through them, they disappear, and a quantity of water equal in weight appears in their place. There is not the slightest parity between the passive and active powers of the water and those of the oxygen and hydrogen which have given rise to it. At 32° Fahrenheit, oxygen and hydrogen are elastic gaseous bodies, whose particles tend to rush away from one another with great force. Water at the same temperature is a strong though brittle solid, whose particles tend to cohere into definite geometrical shapes. Nevertheless we call these and many other strange phenomena *the properties of water*, and we do not hesitate to believe that in some way or another they result from the properties of the component elements of the water. We do not assume that a something called 'aquosity' entered into and took possession of the oxide of hydrogen as soon as it was formed, and then guided the aqueous particles to their places in the facets of the crystal. Is the case in any way changed when carbonic acid, water, and ammonia disappear, and in their places, under the influence of pre-existing living protoplasm, an equivalent weight of the matter of life makes its appearance? What better status has 'vitality' than

'aquosity' and why should 'vitality' hope for a better fate than the other 'itys' which have disappeared?

"If scientific language is to possess a definite and constant signification, it seems to us that we are logically bound to apply to the protoplasm, or physical basis of life, the same conceptions as those which are held to be legitimate elsewhere. If the phenomena exhibited by water are its properties, so are those presented by protoplasm, living or dead, its properties. If the properties of water may be properly said to result from the nature and disposition of its component molecules, I can find no intelligible ground for refusing to say that the properties of protoplasm result from the nature and disposition of its molecules."

In these sentences we have endeavoured to give in his own words the gist of the Professor's argument for life being due to the nature and arrangement of the elementary particles. There are certain statements of facts, also certain inferences; the question is, Do these afford us the slightest help towards understanding the real subject of inquiry? While no one is disposed to deny that, subject to certain qualifications, the substance of which the bodies of all animals, and even also of vegetables, are composed, has a certain chemical correspondence of character, this statement, as we have said, must be qualified; for all flesh is not the same flesh, although all flesh has certain points of resemblance. Admitting the case, however, as put to have a measure of scientific truth in it, we have no objection to accept the designation which Mr. Huxley gives to this organized substance, of being the *physical basis* of life, *i.e.*, the substance in connection with which alone life is exhibited. Moreover, we believe that the *physical* properties of protoplasm, just as the *physical* properties of water, are the result of the nature and disposition of its molecules; but the learned Professor must see as clearly as most of his readers do, that the question, What is the cause of life and of vital phenomena? is not to be settled in this easy, off-hand manner. These phenomena

are very striking and mysterious, and differ so essentially from the phenomena of physics, that mankind have generally concurred in separating physiological phenomena from those of pure physics. It certainly does not follow logically, as Mr. Huxley would have us believe, that because the physical properties of water and of protoplasm are due to the nature and disposition of their molecules, or atoms, therefore the phenomena of organic structure, and of sensation and thought, are also due to the same cause. To declare that this is a necessary and logical conclusion is a mere asserting of the point which the writer wishes to establish. Nothing is adduced to prove the position, or even to render it probable; the assertion, though it is thrown into a seeming logical form, is destitute of all logical consistence; and the greater part of mankind will still continue to think that vital phenomena require for their explanation the assumption of a principle entirely apart from all we know of physical law, and that till we know more about it than the Professor has explained, it will be better to regard the philosophy of life as a mystery yet unsolved.

When the writer of the lecture alluded to states, as the foundation of his argument, that the material of which the bodies of all animals are formed is substantially the same protoplastic substance, it seems to us that he thereby employs the strongest imaginable argument against his theory; for if the molecules in every case are the same in nature, and in chemical arrangement, as he declares to be the case, it may well be asked, Why, then, have we the infinite variety of form and character observed in the different animated tribes? Does the variety of form and organic structure not rather indicate the presence of a non-protoplastic principle, engaged in arranging the molecules so as, out of what appears so homogeneous, to evolve in one instance a lion, in another a lamb, or an eagle, or a fish?

It is not difficult to find a simple and natural reason for all protoplasm being to a certain extent correspondent in

chemical character. The reason seems to us much the same as that which we assign for carriages of all kinds possessing wheels, namely, in order that they may be carriages, *i.e.*, in order that they may have a more easy locomotion. On the same principle it is evident that, so long as animal functions require to be what they are, it is necessary that animal tissues should possess a certain physical character; for instance, that its molecules should be so arranged that they may, in consistence with a well-known chemical law, be held in very feeble combination, for thus alone can digestion, assimilation, and other complex processes of life be conducted. If, then, we may correctly hold the wheels of a carriage to be the active propelling cause of its locomotion, then, and not till then, may we hold that the chemical constitution of protoplasm is the cause of life.

The questions, What is protoplasm? and what are its physical properties? are questions strictly scientific, which may be investigated and explained by chemists and physiologists; but the questions, What is life? and what is the cause of vital phenomena? stand in a very different position, and require something more than the microscope and testing-tube to explain them. The materialist sees the brain and the nerves and the flesh; and he sees sensation and thought existing in local connection, and, we may practically say, in necessary connection with them; and though the physical organs of thought afford him no more explanation of the psychical phenomena than the wheels of a carriage afford of the cause of locomotion, yet the zealous externalist, whose arguments we have been presenting to the reader, endeavours to satisfy himself and the public generally, that there is no escape from the conclusion that the one is the cause of the other—that the brain is the originating cause of thought. This seizing hold of the first thing that offers, and jumping to a conclusion regarding its functions, is exceedingly unsatisfying to the philosophic mind.

In seeking to understand the great question of animal

life, the mind very soon becomes convinced that it can receive little or no illumination from without, and that if we confine ourselves to the *properties of matter* we thereby exclude consideration of the principal phenomena connected with animal life. When we contemplate these phenomena we find that, if they are to be understood, it can only be by the exercise of wider and higher functions of the mind.

Exercising ourselves thus we start with the fundamental belief that nothing occurs uncaused, and with its corollary, that unless we assign a *sufficient* cause for any phenomena or event we assign no cause at all. It is thus, and thus alone, that the reflecting portion of mankind will be brought to predicate an intelligent, invisible cause, not only for explaining the external physical machinery of the world, but much more to account for the indications of intelligence which are observed animating the living creatures on the earth's surface.

The author of the lecture on protoplasm, by the language he employs throughout most of the paper which we have been discussing, impresses the reader with the conviction that he is a strenuous materialist, and that he is satisfied that protoplasm produces both organization and thought. But before he concludes and parts with the subject, he surprises his readers by explicitly repudiating a belief in matter. His brief but rather enigmatical remarks may yet be sufficient to introduce us to a new phase of thought which we may designate, from its chief characteristic, the philosophy of ignorance.

He concludes thus: "Undoubtedly the terms of the propositions I have placed before you are distinctly materialistic, nevertheless two things are certain; the one, that I hold the statements to be substantially true; the other, that I individually am no materialist, but, on the contrary, believe materialism to involve grave philosophical error.

"This union of materialistic terminology with the repudiation of materialistic philosophy, I share with some of the most thoughtful men with whom I am acquainted;

and when I first undertook to deliver the present discourse, it appeared to me to be a fitting opportunity to explain how such an union is not only consistent with, but necessitated by, sound logic. I purposed to lead you through the territory of vital phenomena to the materialistic slough in which you find yourselves plunged, and then to point out to you the sole path by which in my judgment extrication is possible."

Mr. Huxley, however, before this extrication of his hearers and readers from the slough of materialism, gives them one more plunge in it, thus: "While it is a philosophical impossibility to demonstrate that any given phenomenon is not the effect of a material cause, any one who is acquainted with the history of science will admit that its progress has in all ages meant, and now more than ever means, the extension of the province of what we call matter and causation, and the concomitant gradual banishment from all regions of human thought of what we call spirit and spontaneity."

We are not aware that there has been any special modern triumph of materialistic philosophy. We have indeed no doubt that in certain minds there is a tendency to materialism, the result of a too narrow and exclusive study of physical science. We know and acknowledge freely, also, that in barbarous times, eclipses, storms, and earthquakes were universally regarded as supernatural expressions of Divine wrath. We are not, however, aware that it has been shown by modern physicists, that though these and other startling phenomena are the result of unvarying physical law, therefore they cannot be in accordance with the Divine will. On the contrary, it seems to us that even the unlearned in our land are coming more and more to see that the Divine will is necessarily expressed through the operation of those laws of nature which Himself has instituted. It is therefore only with this all-important reservation that we can at all accept the assertion that the facts of science necessarily banish the belief in spirit and spontaneity. We therefore suggest that Mr. Huxley's sentence should be read thus: That the facts

of history and of science, and the study of philosophy, alike banish the belief that the Divine Being, judicially or ministerially, rules the earth by a derangement of those laws of nature which Himself has instituted.

When the author of the paper, then, utters the prediction that the physiology of the future will certainly extend the realm of matter and law until it is co-extensive with knowledge, with feeling, and with action, in one sense we accept the justness of the remark. We believe that science will show us more and more clearly how closely we are connected with a physical system, and that our knowledge, our sensations, our feelings are in this world dependent upon, and, in one sense, are impossible without, certain movements in our physical organism. This admission, however, let us inform the Professor, no more banishes the belief in spirit than the study of the cranks, wheels, and shafting of the steam-engine banishes the belief in steam-power. The mind is still the unseen thinking principle, however closely it may in this world be connected with a physical organ which gives outward expression to it, and also, as we have said, gives a certain physical character to its action, impressing time and space and form, more or less, even upon its most abstract conceptions. Were Mr. Huxley equally just to philosophy as he is favourable to physics, he would acknowledge, we think, that there is nothing incongruous in believing that though nature's laws are uniform they may yet be the result of direct spiritual and voluntary agency, and he would also see that though knowledge and voluntary action are in a physical world dependent on physical power, as their necessary exponents, yet thought and volition are not even conceivable as the result of mere physical action.

Having given the most lively expression to materialism, the author of "Protoplasm," before concluding, favours us with what may be held his own more esoteric opinions on the subject. "But after all," says he, "what do we know of this terrible 'matter,' except as a name for the unknown and

hypothetical cause of states of our own consciousness? and what do we know of that 'spirit' over whose threatened extinction by matter a great lamentation is arising, except that it is also a name of an unknown and hypothetical cause or condition of states of consciousness? In other words, matter and spirit are but names for the imaginary substrata of groups of natural phenomena.

"But if it is certain that we can have no knowledge of the nature of either matter or spirit, and that the notion of physical necessity is something illegitimately thrust into the perfectly legitimate conception of law, the materialistic position that there is nothing in the world but *matter*, *force*, and *necessity*, is as utterly devoid of justification as the most baseless of theological dogmas. The fundamental doctrines of materialism, like those of spiritualism and most other 'isms,' lie outside the limits of philosophical inquiry.

"In itself it is of little moment whether we express the phenomena of matter in terms of spirit, or the phenomena of spirit in terms of matter; matter may be regarded as a form of thought, thought may be regarded as a property of matter —each statement has a certain relative truth."

What, we ask, is Mr. Huxley's exact meaning when he expresses himself thus? Is he a pure idealist?—matter, says he, may be regarded as a form of thought; or is he a materialist?—thought, says he, may be regarded as a property of matter; or is pure positivism the only philosophy? for one thing is certain, namely, that he considers it wrong to believe in matter, and equally wrong to believe in spirit, and that it is folly and illusion to believe in a Divine cause of phenomena. This, it will be confessed, is a hard task which the expositor of physical science imposes on the thinking public. We do not believe it is possible to realize it. If there is any one unvarying law of human thought, it is this, that we *must* believe in a cause for all phenomena. Now, we have never heard of mankind possessing any ideas of cause except as connected either with matter or physical force, or with mind

finite, or mind infinite. If we can change this law of our nature, then may we realize that condition for which Mr. Huxley so devoutly longs. But it appears to us that the attempt to view the world as a mere succession of unconnected, uncaused phenomena will neither improve man intellectually nor morally.

For ourselves, we experience nothing but difficulty in our attempts to understand this new philosophy. We would like, for instance, to know how we are to express the phenomena of spirit, such as thought, judgment, and volition, in terms of matter. Certainly we cannot do so by making thought and matter identical. But leaving this, we have further difficulties. Though materialism has always seemed to us an irrational and foolish theory, insomuch as it maintains that material molecules are the only existences, and that these only require to be properly arranged to become at once the cause and the possessors of thought, their movements being the expression of it, yet this newer philosophy, in which we are to express thought in terms of matter, and are yet to believe neither in matter nor in spirit, seems to us infinitely more inconceivable. No doubt we constantly express thought by means of external symbols, such as letters or pictures or vocal sounds, but this is a simple case; for when we talk of such symbols expressing thought, we assume that there is an intelligent principle which exists and is the interpreter of the symbols. But, as Professor Huxley would have us believe, that it is neither matter, nor spirit, nor any other entity which interprets the movements of which he speaks, his views are to us entirely incomprehensible.

That we should admit our ignorance of the specific nature of matter, and of the specific nature of mind, appears to us a mark of wisdom, but to proclaim a disbelief in both the one and the other is to deny all existence, and is a position which no rational mind can sanction. It is simply an impossible conception.

That matter, viewed as an aggregation of independent

unconscious atoms, cannot by any mere process of arrangement become the cause of consciousness and intelligence, was the sturdy old objection to ordinary materialism, and we doubt if a more formidable objection can be employed to expose its irrationality.

But some other forms of materialism may present themselves. Thus, casting aside the current belief in *matter* as a thing consisting of eternal hard particles, and regarding the world, organic and inorganic, as a system of pure dynamics, with intelligence neither inherent in it nor presiding over it, nor influencing it in any way, we ask, Can the human mind in the exercise of reason bring itself to believe that a spontaneous arranging of such forces, in obedience to a law inherent in them, may possibly evolve the phenomena of mind? Such a theory has been proposed. All we say is, that it has never been wrought out as a rational theory. It is just another form of materialism, but which seems even more irrational; for matter, in the ordinary sense of the word, implies an entity occupying space, and capable of action; but energy, or force, separate from all cause, material or spiritual, is inconceivable; for force we only conceive as the action of some being or thing. Self-existent eternal force, without consciousness and without intelligence! the idea is sublimely inconceivable, and sublimely irrational.

Though all ontology involves questions transcending the powers of the human mind, and perhaps also of the angelic mind, yet we cannot but hold it more consistent with our rational nature to assume that an intelligent principle exists and acts throughout nature, than to conceive either blind matter or empty force sustaining such onerous functions, and finally evolving moral and responsible beings. On the supposition that the physical world is a direct manifestation of Divine power, it is not of course necessary that we regard every separate part or object either as possessing intelligence, or as acting by virtue of its own power; this would seem inconsistent with the unity which we conceive to be the

characteristic of mind and intelligence; but we may correctly conceive a one intelligent power everywhere present and energizing, according to physical law, and thus giving to us short-sighted beings the impression of localised power, and of that adaptation of means to ends which we call physical cause and effect. Nor need physical law act merely like a machine, repeating itself. We may conceive its arrangements so contrived as by a far-reaching forecast to evolve a progression to ever higher and higher results. Such arrangements being not the less sure because we cannot trace their details, nor the results less in accordance with intelligence because they are accomplished in accordance with physical law.

While, however, it is impossible to hold that either energizing matter or energizing force can exist without a cause for their energy, or that physical force or unconscious matter can evolve consciousness, it is a very different position to hold that the mind of living beings may be so connected with physical organisation that it shall receive impressions, and shall exert volition only through this medium—and more than this, that even the character of thought shall be moulded and fashioned more or less closely on the physical type—the mind picturing to itself even spiritual and abstract things according to a physical model, and having its powers measured and proportioned by the functional strength of the cerebral organ. It is quite possible, we say, that every thought of man and of the lower animals is capable of full realization only through the action which the mind produces in this organ, and that the cerebral organ may react on the mind, and furnish it with the physical symbols necessary in human and in all animal thought. The physical element, however, in such a supposition as the one we have expressed, is neither to be regarded as the cause, nor originator, nor yet as the subject of thought, but only as the accompaniment and *sine qua non* of thought in beings intimately connected with a physical world as we are.

We may state the argument against the materialist in this way, and the reader will pardon this condensation of the argument. *If all is matter*, then *What is thought? Thought must either be matter itself, or the movements of matter;* and to explain perception, the materialist must hold *matter either to be conscious of itself, or to be conscious of its movements.* But as neither mere matter nor mere material movements have any perceived resemblance to thought, so neither can we hold the *consciousness or perception of these to be thought.* To conceive thought we must therefore assume the existence of an appropriate thinking principle.

But, to return to the wider question, there are other aspects which, at first sight, may appear more promising than the theories of pure atheistic materialism, and two of these we shall allude to, and thus bring this chapter to a close.

Suppose, as formerly suggested, that it be admitted that neither dead matter nor blind force possesses those inherent qualifications which are necessary to form a cosmical system such as ours, and to stock it with self-conscious creatures, it may be asked, Is the opinion not a good and tenable one, that matter has active properties conferred and sustained in it by the Divine Being? and may the same Being who gives it its physical powers not also confer upon it, as one of its most important properties, the power of thought, so that, speaking in consistence with what we see, we may hold cerebral action to be the cause, or producer, or fabricator of thought? We reply, that to hold such an opinion implies a very great confusion of ideas, in more ways than one; for, in the first place, physical movement, as we have just shown, is one thing, and thought is another and totally different thing. But, besides this, if matter, as this supposition infers, has no natural or inherent power of thinking, but both our thoughts and the movements of the brain which are here assumed to cause them, are God-produced, then, clearly, the thoughts are not, correctly speaking, the creature's thoughts, but the thoughts of God. In holding such a theory we therefore not only

subvert our conceptions of the moral economy of the world, we also stultify the general belief in the individuality and freedom of man's will.

Suppose then, again, that we vary the theory, and regard the world, organic and inorganic, not as material, but as a system of Divine dynamics, it may be asked, Should we not on this supposition be justified in holding that He who is the author of all our organic activities may give such subtle dynamical action to the cerebral organ as may constitute thought? The same objections very evidently apply to this as to the view immediately preceding; for by representing physical dynamics and thought as identical, we receive no help; for physical movement we must ever regard as one thing, and thought as another thing. The view is also pantheistic, and makes the Deity the author of our errors, follies, and crimes.

These various theories seem to us to exhaust all the suppositions that can be made in consistence with realism. They are very easily stated, but, nevertheless, if we keep them distinctly before us, they may lead us to see more clearly the separate nature of mental and physical existence.

To be consistent, then, it seems to us, that we must view the subject of mind and of physics in this light.

First, that Deity has out of His own essence created spiritual, intelligent beings, with freedom of thought and the responsibilities which are inseparable from all independent existence.

Second, that the laws which regulate organic and inorganic nature are but the methods of the Divine government —the energy and power necessarily emanating from the Being who has willed the physical system to exist, and who sustains it in action.

From this it follows necessarily and logically that physical objects, such as the sun and the moon, the earth and its various ingredients and parts, including all physical organisms, are not in any true sense the causes of action. They seem so

to our apprehension, and in this light we may still regard them as the immediate or instrumental causes of physical action and phenomena; but strictly speaking they are mere exhibitions of localised power, which emanates from the supreme and omnipresent Being.

Third, that while the supreme Being is the true cause of all physical action, all living creatures are, as regards their sentient and intelligent nature, independent agents, by virtue of the spiritual nature of the mental principle conferred; and we hold the the power of thought to be essentially the function of such independent spiritual beings, and that this function has, therefore, no necessary dependence on the laws of physics, though in this world sensations are evoked, and thought is modified and toned and, as we shall by-and-by see, helped by our physical connection. Of this we shall have occasion to speak more fully in a subsequent chapter.

CHAPTER IV.

THE GENESIS OF ANIMAL LIFE AND ORGANISATION—SPECULATIONS — TRANSMITTED LIFE — TRANSMITTED MIND — HABITS, ETC.—TYNDALL'S VIEWS.

THE genesis of animal life and organisation is so wonderful that, in contemplating it, the scientific and the unscientific are alike drawn into the region of speculation. Is the formation of the animal in the womb of its parent to be explained by any known laws of matter? or is it to be ascribed, according to the popular belief, to the direct and special interference of Deity, unconnected with all known physical law? or, third, can we ascribe the building up of the animal organism to an influence apart from matter—call it mind, life principle, or some such spiritual agency, enclosed within the ovum, and acting as a formative power, either identical with the sentient principle or associated with it?

Aristotle, differing somewhat from us, held, not that the mind was in the body, but rather that the body was in the mind, and was everywhere pervading and animating it. In watching the movements within the little albuminous sac which constitutes the animal *ovum*, it is not difficult to fall into Aristotle's idea, and to deduce a theory. Thus when, after impregnation, we see the ovum begin a process of spontaneous dividing and subdividing into minute cells, the impression is irresistible that there is life in the microscopic mass. And when, following this, we see certain of these prepared cells arranging themselves towards one part of the circumference into two membraneous leaves, between whose folds by-and-by appear the embryonic groove which is to

form the keel of the proposed structure; and when we see more and more of these cells drawn constantly around this groove, until presently the rudimentary organs, external and internal, begin to show themselves rudely blocked out of the transparent cell-material,—how natural, in these circumstances, is the impression that the soul of the creature exists within the globule, and that it has been struggling, not ineffectually, to clothe itself with a material garb! Is it the soul of a man, of a lion, an ox, or a mouse which is arranging the contents of the spherule? As yet we can give no deliverance; but by-and-by there will be an avatar, and the spirit will show its nature by the limbs and organs which it will assume, and by means of which it will fulfil its destiny in passing through this narrow zone of life which we call the world.

If there is mind within the ovum previous to organisation, whence is it derived? Is it a new creation? or is it derived from the life principle, or soul, of the parents? It appears with all the parents' powers and instincts, perhaps with some of their acquired habits, and even, we may sometimes find, with certain of their educational knowledge.

Sir Charles Lyell, in his "Principles of Geology," informs us that pups whose parents have been instructed in the diverse arts of pointing, and carrying game, and hunting deer and peccari, and of herding sheep, enter upon field work as if they had been previously instructed in the difficult and various artifices to which their parents had been drilled; and he gives some curious instances of this which go far to draw us to conclude that, not merely natural instincts, but also knowledge artificially instilled, is, to a certain extent, transmitted from parent to offspring.

From the living parent the vital substance of the offspring is derived, and with the life of the offspring its mind, or thinking power, is associated. It seems then not an unnatural supposition, that the mind of the offspring is derived from the mind of the parent. This theory seems to acquire some countenance from the facts above alluded to, bearing upon

transmitted habits; it seems also to be in some analogy with the phenomenon observed in connection with the growth of separate centres of volition in the body of polyzoic animals.

In a physical world it would seem necessary that all should be conducted in accordance with uniform law, and we accordingly see that this appears ever in connection with certain physical conditions. But though we see these conditions present, we never discover the reason why these conditions should result in the production of organic structure, or of life and self-conscious existence; the conditions, we say, are totally inadequate to account for the production of the phenomena.

Science, no doubt, tries to show us all the conditions which are essential steps in the process; and attempts are even made to work out a reasoned theory. Mr. Herbert Spencer, by an ingenious analysis of physical, physiological, and psychological phenomena, has attempted to connect together the laws which he thinks pervade alike all these departments, so that we may possibly understand how the heterogeneous is evolved from the simple and monogeneous. No one, we believe, will be more ready than this author to acknowledge the difficulty of the task, or to admit to how very limited an extent we can succeed in satisfying ourselves with any such reasoning. We are glad that this author, notwithstanding a laborious study of physics, can yet believe in the existence of more than appears on the surface, and that he has satisfied himself that matter, motion, force, and mind are but symbols of an unknown reality. ("First Principles," 1867).

The animal is not only a mysterious, it is a complex, phenomenon, and there are many problems involved. Thus, first, there is the consideration of the nature of the physical *atoms* of which all animal substance is composed.

Secondly, there is the nature of the animal *substance* itself, and those tissues which physiologists observe to be in a state of constant disintegration and reconstruction; a process which is found to be essential to all animal life.

Thirdly, there is what we vaguely call *animal life*, a term which is often applied indifferently to life and to consciousness of existence. The two are, however, frequently observed separate, and they must therefore be distinguished. Thus the plant has what is called life, but it has no consciousness, and we can sometimes observe the same to be the case with regard to the animal. It may have life, *i.e.*, the usual bodily functions may be discharged, but so far as we can discover there is no consciousness. This is the case when an animal is under the influence of narcotics, or in a state of syncope; also when there is extensive disease of the brain, or when those parts of the cerebrum which connect the mind with the corporeal machine are artificially removed.

Then, lastly, there is the *mind*, or thinking principle.

To fix what we mean by each of these is not only a very important task, but it is also a very difficult one, and equally difficult is it to determine the mutual relation which exists between them. What we see is called animal substance, and what we may regard as parts of a complex machine. These certainly reveal to us how curiously and wonderfully we are made; but they rather cause the neophyte to shrink back, appalled at the fragility and perishableness of his nature, than inspire him with admiration of the workmanship, or help him to recognise *himself* in them.

The brain especially, which is, without doubt, the most complex and inscrutable organ, how helpless a mass it is! It can neither move nor help itself in any way. It may sometimes be removed, slice after slice, without the animal being conscious of what is going on, or experiencing any pain; and yet we must believe that our thoughts and speculations, our pains and enjoyments, are entirely dependent on it. In viewing it we ask inwardly, Is this all that constitutes man and makes him the possessor of reason and of those thoughts which wander through eternity—this small mass of soft, pulpy, granular matter? And is there nothing absolutely in the world but matter? How humbling a belief!

Perhaps we cannot bring the question of animal organisation in one of its aspects better before the reader than by transcribing part of a paper read by Professor Tyndall to the Mathematical and Physical Section of the British Association, held at Norwich in 1868. He states the question under the light in which it then appeared to him, with his usual clearness and vivacity.

"With reference to crystallization, the scientific idea is, that the molecules act upon each other without the intervention of slave labour; that they attract each other, and repel each other, at certain definite points, and in certain definite directions; and that the pyramidal form (say, of common salt) is the result of this play of attraction and repulsion. While, then, the blocks of the Pyramids in Egypt were laid down by a power external to themselves, these molecular blocks of salt are self-posited, being fixed in their places by the forces with which they act upon each other.

"Throughout inorganic nature we have this formative power, this structural energy, ready to come into play and build the ultimate particles of matter into definite shapes. It is present everywhere. This tendency on the part of matter to organise itself — to grow into shape, to assume definite forms—is, as I have said, all-pervading. It is in the ground on which you tread, in the water you drink, in the air you breathe. Incipient life, in fact, manifests itself throughout the whole of what we call inorganic nature.

"And now let us pass from what we are accustomed to regard as a dead mineral to a living grain of corn. In the corn the molecules are also, as in the crystal, set in definite positions. But what has built together the molecules of the corn? I have already said regarding crystal architecture, that you may, if you please, consider the atoms of molecules to be placed in a position by a power external to themselves. The same hypothesis is open to you now. But if in the case of crystals you have rejected this notion of an external architect, I think you are bound to reject it now, and to

conclude that the molecules of the corn are self-posited by the forces with which they act upon each other. It would be poor philosophy to invoke an external agent in the one case, and to reject it in the other.

"Let us now place the grain of corn in the earth, and subject it to a certain degree of warmth. In other words, let the molecules both of the corn and of the surrounding earth be kept in a state of agitation; for warmth, as most of you know, is, in the eye of science, tremulous molecular motion. Under these circumstances, the grain and the substances which surround it interact, and a molecular architecture is the result of this interaction. A bud is formed; this bud reaches the surface, and as the common motion of heat enabled the grain and the surrounding substances to coalesce, so the specific motion of the sun's rays now enables the green bud to feed upon the carbonic acid and the aqueous vapour of the air, appropriating the constituents of both, for which the blade has an elective attraction. Thus forces are active at the root—forces are active in the blade—the matter of the earth and the matter of the atmosphere are drawn towards the plant, and the plant augments in size. We have in succession the bud, the stalk, the ear, the full corn in the ear. Now there is nothing in this process which necessarily eludes the power of mind as we know it. The duly expanded mind would see in the process and its consummation an instance of the play of molecular force. It would see every molecule placed in its position by the specific attractions and repulsions exerted between it and other molecules; nay, given the grain and its environments, an intellect the same in kind as our own but sufficiently expanded, might trace out *à priori* every step of the process, and by the application of mechanical principles would be able to demonstrate that the cycle of actions must end, as it is seen to end, in the reproduction of forms like that with which the operation began. All that has been said regarding the plant may be restated with regard to the animal. Every

particle that enters into the composition of a muscle, a nerve, or a bone has been placed in its position by molecular force. And, unless the existence of law in these matters be denied, and the elements of caprice introduced, we must conclude that, given the relation of any molecule in the body to its environments, its position in its body might be predicted. Our difficulty is not with the *quality* of the problem but with its complexity."

Professor Tyndall's argument is identical with that employed by Mr. Huxley in the lecture on Protoplasm, on which we have commented. It is substantially this: We admit that the form of a crystal depends on the play of forces which the atoms exert on each other, therefore we are bound to believe that the legs and arms of man, the wings of birds, and the form and structure of all animal and vegetable organisms are, in like manner, due to the forces inherent in their molecules, without any reference to an external power, in other words to an Architect.

We have always derived very great pleasure from the writings of Professor Tyndall. His lively, elegant, and telling style never fails to infuse interest into the subject of which he treats. No man, however, is infallible; and in the present instance we take objection to every part of his position, both to the premisses and the conclusions.

The argument is addressed to the popular mind, and it professes to be founded on an unquestioned article of popular belief. When we examine, however, this belief, we find that far from being a thoughtful, well-considered conviction, it is a mere loose popular form of expression. Now, we need not say that a difficult philosophical question is not to be settled by reference to a popular form of speech, especially when the form is held evidently only for convenience' sake, and is admitted by most of those who adopt it to be philosophically incorrect. The popular language is, that the sun and the earth mutually attract each other *by virtue of powers with which they are endowed.* This, from its convenience, will

probably always be the form of expression employed. It is brief and intelligible, and prevents the necessity of periphrastic explanations. When we examine the question, however, we do not find that the public any more than the purely philosophical portion of the community are disposed to admit that attraction and the other energies of nature are conducted irrespective of Divine power. On the contrary, the large majority, both of the learned and unlearned, agree that without the sustaining power of Deity the laws of nature could not subsist. This is clearly equivalent to acknowledging that the power which is apparently localized in the physical bodies emanates truly from the Being whose power pervades all nature and all space. Professor Tyndall therefore founds his theory of animal structure upon that which, as we have said, is a mere form of expression, and which, far from being accepted as true, is acknowledged to be false: so much for Mr. Tyndall's premisses.

Then, as to the conclusion built upon them. Let it, for argument's sake, be admitted that we do believe that the operations of inorganic nature are due to independent powers inherent in matter, irrespective of any sustaining external influence. We ask, Does it follow of necessity from this, that the formation of animal and vegetable organisms is due to the same powers? Because we believe that mountains are upheaved by mechanical force, must we believe that the same force will account for elephants and whales, for eyes and ears, brains and thoughts? This position seems to us so entirely irrational that we can scarcely bring ourselves to debit so learned a writer with it, and yet we do not see how we are otherwise to interpret Mr. Tyndall's meaning, when he says that the laws of pure physics are applicable to vital phenomena. Of course every one admits that the power which places the molecules in their positions, and builds up animal and vegetable organs, is a physical power: it requires physical power to move every physical body, whether it be a mountain, an atom, or a molecule. We admit, therefore, as Mr. Tyndall

expresses it, that if we possessed minds to see the play of force which draws each molecule into its position, we would see that this is done by the application of specific mechanical forces. This we think no one will deny. But the question is, What is the cause of these forces, and why are they so specific as to produce such specific results? Everything must depend on the action and direction of the forces; they are not centripetal, as we see them in ordinary inorganic action; nor are they this centripetal force, modified by the forms of the molecules, as in crystallization. On the crystal each part is a repetition of the one elementary form. The body of an animal is in striking contrast: it is a corporation of parts where each has a separate form and a separate function; and where at the same time the *many* subserve the necessities of the *one*, the prominent object of that *one* being self-subsistence, enjoyment, and the propagation of the species. What then guides the molecules to produce such results? Mr. Tyndall scouts all idea of architectonic skill and external influence. All the power and skill with him lies within the molecules. With us, the molecules, as physical bodies, possess neither power nor skill of their own. All power and all skill emanates from the living and not from the dead, from the conscious and not from the unconscious, from the one great source of power and wisdom, or from finite intelligence.

The molecules and their movements are but the methods of the working of intelligent power; and we appeal to the common sense of mankind to decide, whether the characteristics of wisdom and design which we observe in organic structures can more rationally be attributed to the action of an all-pervading mind, or to the action of an unconscious entity, whence all mind and all design, present or past, are excluded; for Mr. Tyndall's views of inherent molecular power seem to lead necessarily to this position.

We confess the difficulty of all ontological questions, and therefore we merely say that to us the position assumed by Professor Tyndall appears irrational. Those, again, who hold

the theory that a delegated power is conferred on matter, we leave to work out their theory if they can; and to show how such powers can be caused to inhere in matter except by the operation of a direct and continued causing power. For our part we find it much more easy, simple, and natural to regard Deity as the direct cause of physical and physiological action, and to regard the mind, or thinking principle, of the creature as formed of the spiritual essence of the Being who is the eternal possessor of wisdom and power.

It is evident that a man who determines to believe in nothing that does not impress the senses can never rise to the belief in an unseen Being. Such a conception can only be reached by such as desire to comprehend the whole phenomena met with in the world. And, let us say, science would be comparatively a poor affair if it only allowed a man to exercise his eyes and ears and finger ends. True science seeks to advance truth by the strenuous exercise of all the faculties—sight, hearing, reason, and a questioning of our whole nature.

Let us end by a question addressed to those writers whose views we have been here considering. It is this: If man is nothing but protoplasm, and we are not allowed to believe in mind as a spiritual principle, how are we to account for protoplasm so frequently misdoubting its own ability to think and feel and act the part of a man? Why does it gratuitously dispossess itself and enthrone spirit, declaring the immaterial principle to be the monarch, and the molecular organs to be merely the scaffolding erected for accomplishing the designs of a principle different from itself? This seems a vicious and abnormal position for pure protoplasm to assume. We ask, Can the physicist account for so wonderful a natural production as protoplasm passing so unnatural and false a judgment on itself?

CHAPTER V.

SENSIBILITY, SENSATION, AND THOUGHT.

LET us endeavour to form clear notions of the difference between *sensibility*, *sensation*, and *voluntary thought*. The two former are sometimes confounded in our thoughts, and still more frequently in our language. Thus the word sensibility is sometimes applied indifferently to the consciousness of pain, light, heat, touch, which is experienced by living animals, as well as to the effects produced on inanimate objects by external agents, as if sensibility and consciousness were the same.

Sensibility, in a broad sense, is a susceptibility to be acted on or moved by external causes. Thus we say that a balance has great sensibility when it vibrates under a slight touch. We say also, that plants have a sensibility to light and heat. Chemical compounds are also said to have sensibility when changes are induced in them by the agency of small additions of extraneous substances. Animal tissues show an extreme sensibility to various reagents.

The sympathetic nerves are affected by their appropriate *stimuli*, and on this sensibility, and on the action which it induces in them, the active functions of the heart, stomach, and other internal viscera, largely depend. Notwithstanding the constant sensibility of these nerves, it is remarkable that when the viscera are in health we have no consciousness of their action. Animals, and especially the Batrachia, when they have been recently deprived of life, may have any of their limbs thrown into violent convulsions by the laceration

of the sentient nerves; but here of course, though there is sensibility, there is no consciousness or sensation.

Sensation, as distinguished from sensibility, we hold to be the attribute of a peculiar principle connected with animal life, and which we call the mind, or, more broadly, the *percipient principle.* Let us then clearly distinguish between consciousness and sensibility. We can understand, or at least theorise on, the cause of sensibility in all the cases which we have alluded to, but sensation, or consciousness, remains a mystery to the human mind, and all attempts to analyze or simplify it, or to assign a natural cause whereby to explain it, are eminently unsatisfactory. The chemical elements which compose animal substance being generally admitted to possess no consciousness, either singly or in chemical combination, we seem naturally impelled to attribute consciousness to a something which in its essence is different from mere physical nature; something which we believe to be superadded to, or connected with, the physical substance which constitutes our bodies.

The materialist, however, opposing this view, endeavours to persuade himself that consciousness is the necessary result of the proper chemical combination of physical atoms. This theory, therefore, must either assume that the material atoms possess consciousness, or that though they severally have it not, yet when they are combined in a certain way, and grouped in the order we know by the name of animal organisation, they possess consciousness as the result of this arrangement.

In opposition to this view there exists a loose, unreasoned general notion, that Deity has given to different material atoms or elements their several properties, and that matter, by virtue of these delegated powers, does practically everything connected with the physical world—causes the sun to shine and the rain to fall, the planets to revolve, and every other purely physical operation to hold its course.

Under this theory, or notion, its supporters no doubt find

it difficult to know where to stop; for, first, the question occurs, Does this material power, supposed to be so versatile in its action, cause also the reproduction and growth of vegetable and animal organisms? These are dependent on physical conditions. May this power, which is assumed to be delegated to matter, not be held sufficient to evolve these organisms? And still further, as consciousness is the uniform accompaniment of animal structure, are we to believe that this and the higher phenomena of thought are the natural results of this power, supposed to be conferred on matter? Most men recoil from such extreme conclusions, and yet, as we have said, where are those persons who accept the theory of delegated power to stop? We consider the theory to be entirely unphilosophical and untenable. Though professing to be a theistic theory, it is practically atheistic, and so defeats itself; for if every operation in the physical world may be handed over to matter, what is the place which we assign to Deity? If matter does everything, then clearly Deity does nothing, and need never again interfere in worldly matters.

This atheistic conclusion is only avoided by holding that matter only does what it is told to do; in other words, that its peculiar powers, besides being *given to it*, are *sustained* in it by the operative presence of Deity. If it be so, this certainly alters the case; but in taking this position do we not make the theory of matter ridiculous? For if matter can do nothing of itself, if it requires its powers to be constantly upheld by Deity, then matter is of no use, and is practically a nonentity, and to believe in its existence is evidently absurd.

Third, there is another theory, and which we think is worthy of more attention than it has yet received, though we must not forget that many great men, from Newton downwards, have expressed a quiet approbation of it, so far as they succeeded in obtaining a glimpse of it. It is this. If the world, *i.e.* our physical system, has been called into operative existence by a supreme power, then it follows that the Being who instituted such a system must be the continual upholder of it.

With this belief we do wrong to regard the world as a *creation*, in the strict sense of the word. To create implies to call into existence out of nothing, and this is an impossible idea; equally impossible is it to conceive a spiritual being calling into existence, out of his own essence, an entity of an entirely different nature from his own. We therefore, to be consistent, should speak, not of the *creation* of the world, but rather of the institution of a physical system or economy. When we really believe what is implied in this, we see how unnecessary it is to imagine that He who is the source of all power should have had first to create an entity, such as matter, in order to work out His purposes; and then have to secure its action by a constant outputting of His power. The result to which a consistent theistic belief brings us is, that the ultimate or chemical atoms are mere centres of force, and that these by their conjoint and several action constitute the physical world. The world is thus a dynamical system, whose movements are sustained by the direct power of the supreme Being. Believing this, we have pleasure and freedom in studying it; and we experience none of those misgivings and prejudices against physical discovery which a merely theoretical belief in Deity so often engenders.

Then, as regards the sentient principle in nature. While we regard the physical world in the light we have stated, we know no rational objection to the popular theory of *mind*, namely, that the supreme Intelligence has conferred on man and on the inferior animals a measure of that spiritual essence and power which constitutes His own nature; and which, though so limited and adjusted as to suit the position and requirements of each class of creatures, is yet a finite embodiment in each creature of that Divine principle of intelligence which alone is capable of uniting with the Being from whom its essence is derived in exclaiming—I AM. This—the popular view—we repeat, seems to us to be the only possible, rational, and philosophical theory of mind.

Tyndall and Taine both testify to the inscrutable

nature of thought, and declare clearly the impossibility of discovering any causal connection between it and cerebral movements.

Let us first hear what Professor Tyndall says.

"Associated with the mechanism of the human body we have phenomena no less certain, but between which and the mechanism we discover no necessary connection. I feel, I think, I love. But how does consciousness infuse itself into the problem? The human brain is said to be the organ of thought and feeling. When we are hurt, the brain feels it; when we ponder, it is the brain that thinks; when our passions or affections are excited, it is through the instrumentality of the brain. Let us endeavour to be a little more precise here. We hardly imagine that any profound scientific thinker who has reflected upon the subject exists, who would not admit the extreme probability of the hypothesis, that every fact of consciousness, whether in the domain of sense, of thought, or of emotion, a certain definite molecular action is set up in the brain. That this relation of physics to consciousness is invariable, so that, given the state of the brain, the corresponding thought or feeling might be inferred; or, given the thought, or feeling, the corresponding state of the brain might be inferred. But how inferred? It is at the bottom not a case of logical inference at all, but of empirical association. You may reply, that many of the inferences of science are of this character—the inference, for example, that an electric current of a given direction will deflect a magnetic needle in a definite way; but the case differs in this, that though the passage from the current to the needle is not demonstrated, it is thinkable, and that we entertain no doubt as to the final mechanical solution of the problem; but the passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought and a definite molecular action in the brain occur simultaneously, we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable

us to pass, by a process of reasoning, from the one phenomenon to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all the electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem. How are these physical processes connected with the facts of consciousness? The chasm between the two classes of phenomena would still remain intellectually impassable. Let the consciousness of love, for example, be associated with a right-hand spiral motion of the molecules of the brain; and the consciousness of hate, with a left-handed spiral motion. We should then know when we love that the motion is in one direction, and when we hate that the motion is in the other; but the why would still remain unanswered.

"In affirming that the growth of the body is mechanical, and that thought, as exercised by us, has its correlative in the physics of the brain, I think the position of the materialist is stated, as far as that position is a tangible one. I think the materialist will be able finally to maintain his position against all attacks; but I do not think, as the human mind is at present constituted, that he can pass beyond it. I do not think he will be enabled to say that his molecular groupings and his molecular motions explain everything. In reality they explain nothing. The utmost he can affirm is the association of two classes of phenomena, of whose real bond of union he is in absolute ignorance."[1]

Taine expresses himself in terms almost identical. "La condition nécessaire et suffisante d'une sensation c'est un mouvement intestin dans la substance grise de la protuberance des tubercules quadrijumeaux. Que ce mouvement soit inconnu, peu importe; tel ou tel, il est toujours un déplace-

[1] British Association. Norwich, 1868.

ment de molécules plus ou moins compliqué et propagé; rien de plus. Or, quel rapport peut-on imaginer entre ce déplacement et une sensation? Supposez que l'on sache le mécanisme du mouvement qui, pendant une sensation, se produit dans la substance grise, son circuit de cellule à cellule, ses différences, selon qu'il eveille une sensation de son, ou une sensation d'odeur, le lien qui le joint aux mouvements calorifiques ou électriques, bien plus encore, la formule mécanique qui représente la masse, la vitesse, et la position de tous les éléments, des fibres et des cellules, à un moment quelconque de leur mouvement, nous n'aurons encore que du mouvement, et un mouvement, quel qu'il soit, ne ressemble en rien à la sensation de l'amer, du jaune, du froid, ou de la douleur." (*De L'Intelligence*, H. Taine, 1870).

We do not object to these statements so far as they go, but they seem defective in respect that they bear chiefly on sensation, and omit special reference to what must be considered the higher phenomena of mental action, that of voluntary thought. Neither Professors Tyndall, nor Taine, nor Huxley, venture to allude to the mind as a principle which is not only affected by nerve impulse but which acts also spontaneously in generating thought. Now, unless the statements quoted are supplemented by the recognition of the existence of a separate principle, capable of interpreting the movements alluded to, we are left in a very strange dilemma; for how are we to reconcile the fact that the *brain movements* and the sensations and thoughts have no perceptible similarity, and yet that thought is the result of the movements? Are we to conclude that the movements of the molecules are *thought;* or that, though not thought in themselves, they are yet perceived as thought *by the molecules? Where all is physical* it is evident, as we formerly said, that if the movements of the physical molecules are not thought, they must, in some way or other, be the cause of thought to the molecules; that is to say, physical movements having no resemblance to thought, become thought to the physical bodies moved. This physical theory

seems to us a courting of difficulties, and the selecting of it seems the choosing of a position which renders explanation impossible. When, on the contrary, we accept the doctrine of a spiritual principle, whose nature is essentially to feel and think, then how much more easy is it to admit that, though the brain movements have no resemblance or identity with feeling and thought, they may yet by their action excite the mind to its *natural action*, *i.e.* to consciousness and sensation; and we can see also, without difficulty, that the sensations must vary according to the special nature of the physical impressions which produce them. This seems to us a more rational theory than that of Professor Tyndall. And it is still further freed from all difficulty when we consider that all physical action being the action of Divine dynamics, is the appropriate and designed operation of Divine power. This is an idea which, as applied to the subject of perception, we conceive renders this subject at once simple and sublime. It falls, however, to be more fully expanded in a later chapter.

We are ready, then, to admit that certain movements are produced in the substance of the brain by each external impulse sent along the nerves of sense, and that such cerebral movements are followed by particular sensations. We are also disposed to believe that every act of voluntary thought produces a certain cerebral movement. More than this; it seems to us highly probable that these cerebral movements give the sensuous or human character to our thoughts in this world, and which otherwise might be very different. For what is thought as we know it? Is it not principally a calling up and arranging before us of the images of physical things which have been given us through sense. The child at first is merely the recipient of the impressions of sense; very soon, however, he begins to compare and distinguish these impressions, and to make them the materials of thought. The man recalls the images of things that have been seen and felt and known; he compares, reasons on, and enjoys the recovered impressions; and even in thinking of moral and abstract

subjects we shall find that they present themselves to us embodied in somewhat of a sensuous or physical garb, and at least always with distinct time and space properties, for these are essential elements of human thought.

We would again specially call attention to the fact that in this calling up of sensuous images, the act is accompanied by a cerebral action, probably much the same in its nature, though fainter, than that which exists when sensations are impressed on us by external impulse. If there is truth in this view, and it is adopted by nearly all physiologists, then it is evident that the evoking of these mental images through the instrumentality of cerebral action, and the power of controlling and intensifying that action which the mind possesses, may well account for that exhaustion of the mind's organ which we so frequently experience after severe and protracted thought.

When we reflect on the nature of human thought as thus explained, there will be no difficulty, we think, in accounting for the inability to conduct perfected thought when brain-action is suspended by pressure, or by other physical or physiological causes.

The necessity of brain-action for ordinary thought may, at first sight, appear to militate against the belief in the independent existence and action of mind ; and yet such an idea is unwarranted, for the fact that we do not remember any thoughts which occur during coma affords us no absolute evidence of the total inaction of the mind on such an occasion, and certainly none of the non-existence of mind as a spiritual principle ; for if the sensuous images of which we have been speaking are so essential for the full embodiment of human thought, it is evident that the mind without these images must be thrown into a position entirely new, and may be much as if suddenly constrained to express itself in an unknown tongue ; and thought, if it could be practised in such a case, and without the brain-action, and the resulting mental images or sensations, must be entirely different from ordinary thought.

It is quite natural, therefore, to suppose that, before the mind could acquire the art of thinking under the altered circumstances, difficulties very much corresponding with those encountered by a new-born child in interpreting external phenomena would have first to be mastered.

It may be asked again. If the mind as a spiritual principle is the directing-power in thought, how can it be in any measure dependent on physical agency? We reply, though it is the mind that thinks, yet if the mind, in conducting definite human thought, excites cerebral movements and the resulting sensational images, it is legitimate to conclude that these images may be in the highest degree important as symbols both for representing to the mind, and even in a measure for suggesting to it its various steps; and without these cerebral impressions it may be difficult, or even impossible, freely to conduct human thought, which to so great an extent consists in the arranging of images or symbols in accordance with the requirements of reason.

That the mind forms new arrangements, brings into prominence or intensifies former ideas for the purposes of thought, is well known; but how it effects this has always been a difficulty; for, in the first place, it is asked, how can the mind select what is not present to it at the time? and moreover, in connection with the views we have been stating, if the images are such essential ingredients in thought, and if cerebral action is necessary for the production of these images, then how is thought possible unless we concede that the physical movement takes the initiative? There may be different ways, we think, of getting over the difficulty without compromising the dignity of the mind as the inspecting, directing and originating principle. In the first place, do we not frequently observe that there is effectual and well-ordered mental action, although the mind is unconscious of the specific nature of its action? If it be so, then in like manner the mind may have the ability of calling forth in proper succession the cerebro-mental images which are to constitute the fabric

of thought, although in so doing it does not know the exact nature of its psychical action.

Perhaps, however, the easiest way to explain this matter is to consider that the mind has a cerebral as well as a mental or intellectual area of thought constantly before it, just as in ordinary avocations we have external objects of vision and external pictures, notes, and memoranda, to assist us. On somewhat the same principle, from the array of past thoughts, images, and impressions at the time in its horizon, as well as from the cerebral traces, or pulses of cerebral action, existing at the time, it may select what it considers fitting for its purpose. And to render this explanation the more probable, let us take into consideration certain well-known physiological laws.

Every part of the bodily frame is the subject of constant molecular movements of definite kinds; and this is especially the case with the brain, the most active of all our organs; some of these movements have reference to organic life, and others are connected with thought. It is a law of cerebral action, that any movement which has been induced in this organ has a facility and, we may say, a tendency to return and repeat itself. Who has not observed when he has listened to a piece of music over night, how persistently the notes present themselves in the morning: while we are dressing certain passages continue as if sounding through the head, so that we can not get quit of them. These are not recalled by the mind in the ordinary way by memory, which implies an effort, but they are evidently forced upon the attention by the continued action of the brain of which we have been speaking, and, as we have said, for a time we cannot banish the mfrom the mind.

We may give another illustration of the same law of brain-action, and which may serve to explain the part which the brain frequently plays in suggesting ideas. When we have once mastered a series of bodily movements, say a new piece of instrumental music, or a new dancing step, have we not all

observed how easy the repetition of these acquisitions becomes to us. If, then, the brain correctly retains a series of impressions of this kind, and repeats so easily motions it has previously performed, we can scarcely refuse to admit that, in a state of activity, it may suggest ideas by a spontaneous repetition, however faint, of some of the series of movements which it may formerly, and even at very distant dates, have acquired.

If mental images are thus the result of cerebral action, the act of thinking will consist chiefly in selecting and intensifying those images which the mind desires to arrange in the concatenation of thought.

This law of brain-action furnishes us with facts which throw much light on many of our mental powers, and especially on the wonderful faculty of memory.[1] It is in vain to deny the intimate connection of mind with physics. There is a natural tendency, originating no doubt from the highest motives, to overlook this connection in treating of mind, but it will serve no useful purpose; much wiser is it to study the nature of the connections of the two principles, and to recognize fully that the world, as well as the mind, is the work of a Divine hand. A narrow and arrogant spiritualism will lead to nothing but evil. In the present day it is sure to draw upon itself the unmasking of a heavy battery of physical facts; and defeat in such a way is much more dangerous than timely and candid concession.

[1] Professor Bain (*Mind and Body*, by A. BAIN, LL.D., p. 87) has some useful and pertinent remarks on the intimate connection of brain-action and thought. It appears to us, however, that the great question which "excited the curiosity of the elder Scaliger," namely, the cause of memory and thought, is not solved by any mere generalization of physical facts. I remember a chain of thoughts and actions which has passed before me since my days of childhood, and it is likely that these have left traces on the brain which assist my memory. But the I, or Ego, is not the brain. If we suppose, for argument's sake, that another brain has been suddenly formed exactly corresponding with mine in every particular, and with the same marks and traces, we ask, Would the possessor of such a brain be another me? Could he be said to *remember* the past times and past events which I remember? The correspondence of ideas in such different circumstances may be admitted, but the identity of the conscious Egos is inadmissible.

Many excellent men, from recognising the apparent dependence of thought on brain-action, have been forced to the conclusion that at death we are necessarily plunged into a state of suspended consciousness, and which will continue till the hopes of the Christian are realised by his being again united to an organised body. They who hold this belief are reconciled to this interval of oblivion by the consideration that however long it may continue, yet from our inability to measure its duration, the morning of the resurrection will, practically, to each person, appear as if it instantly followed the moment of death.[1] We have endeavoured to show that though the quality, or expression, of human thought is undoubtedly, to a certain extent, determined by our physical connection, yet if we believe in the mind as a separate spiritual principle, the physical connection in no manner necessitates the conclusion that without cerebral movement there can be no thought. To assume this appears to us to be a gratuitous and ill-founded conclusion.

We may remark, as bearing upon this point, that while we admit the fact that persons recovering from coma, produced by congestion of the brain, awake as from a state of unconsciousness, this affords no absolute proof that during the interval the mind has been dormant. We have frequent proof afforded us that there is an inability of recalling thoughts generated during abnormal conditions of the brain. We have, for instance, evidence that during trance, and especially during somnambulancy, the mind is very active, and yet that when the patient recovers he is quite unconscious of the thoughts which have occupied him, and the actions which he has performed during this peculiar condition of the brain. The oblivion, then, experienced by persons recovering from congestion and total inaction of the brain, proves no more than that the mind has an inability to connect

[1] See an able treatment of this subject, from a Christian point of view, by the late H. Bannerman, Esq., of Hunton-Court, Kent, entitled, *A Glimpse at Coming Events*, 1853.

the thoughts which may be then existing with the thoughts which arise during the brain's healthy working state.

Let us in conclusion condense what we think may be held with reference to brain-action.

First, we consider it as established that the brain, in order that it may be the more fitting organ of the mind, is the subject of a law of action which gives it both a facility and a natural tendency to repeat any series of changes which it has once acquired, whether these have been originally induced by outward sensational impression or by mental direction.

Second, that though these cerebral actions or changes are to us the physical symbols of human thought, they are not themselves thought, any more than the sentences in a book are thought.

Third, we must assume the presence of an intelligent principle to interpret these symbols, or we can not conceive thought to exist.

Fourth, though the brain may follow a certain involuntary course of action, and may thus suggest to the mind a train of thought, we are yet conscious that the mind has the power of controlling the cerebral action. We interrupt one chain of thought and we start another; we can, out of a variety of thoughts, reject even those that are most pressing and select others, and follow them out for any length of time which may be prescribed. All this teaches us how wonderfully the brain is adapted to be the organ of thought; but its laws of action go no farther than the establishment of this point; they do not afford a shadow of countenance to the ill-conceived theory that the brain, as a material organ, is the thinking principle.

CHAPTER VI.

THE DEVELOPMENT THEORY AND THE DOCTRINE OF DESIGN—THE NATURAL AND THE SUPERNATURAL IN NATURE.

THE question having been already touched on in a previous chapter, we feel impelled, before passing to the next branch of our subject, to make a few observations on the evolution or development theory as it may seem to affect the doctrine of design. The strength which was supposed to attach to the theistic argument founded on the proofs of design observed in the world, and which is so generally known in this country as Paley's argument, though it owns not Paley as its author, but is at least as old as King David and as Socrates, is supposed by some persons to have been materially weakened by the theory that all living organisms, whether animal or vegetable, have *been developed according to natural law.* The theory has accordingly been viewed with extreme aversion by not a few good men who not only feel it to deal harshly with long cherished opinions, but who consider it to be subversive of religious belief; for if the humblest creatures can be caused to spring from a vegetable infusion decocted in the laboratory, and can be proved amenable to a natural law of development which may raise them from one stage to another, till at length these dots of vitality reach the rank of the highest orders of animal life, then, according to the views of these persons, the belief in Creative Power is shaken, and the Deity is displaced from its position.

We have great sympathy with such as suffer in this way, at the same time we must say that we regard their fears as extremely unphilosophical and ill founded.

We ask such persons in the first place calmly and honestly to consider whether it may not be the case that we have been too much in the habit of literalizing the sublime narrative of the creation, which in its oriental garb is so attractive to the mind ; and whether at this period of the world's advancement it may not be necessary that we submit to have certain of our opinions modified by the influence of modern science, and that thus our belief in the existence and actings of a *supreme Creator and Governor of the world* may be made to rest on deep and solid convictions of the reason, rather than on the acceptance of such interpretations as a less fully instructed and greatly less critical age may have given us. It would seem from what appears, as if we were now no longer to live in the easy enjoyment of any form of belief which will not stand the test of science and a severe criticism. If it be so, and if our interpretations of the earlier historical portions of the Book of Genesis are to be reconsidered and modified, let not the timid and distrustful doubt that views equally simple and sublime will emerge after all crudities and misconceptions, whether scientific or theological, have been removed.

Let us, for argument's sake, assume that the development theory has been established even to its extremest doctrines. We ask, is it true that the argument in favour of design is thereby weakened ? The world is before us in all its complex arrangements and in all its beauty, and we have only to look upon it and to judge for ourselves. Whatever may have been the stages by which it has out of chaos and vacuity been brought to its present completeness, is it possible, we ask, to study it and come to the conclusion that it has reached this state without the operation of mind and purpose ?

When we see a complex system of artificial machinery performing certain important operations, we feel no hesitation in declaring that the machine was contrived for the purposes it is fulfilling. We may go further than this, and say that it is a law of our mental constitution that the more we see of complexity and, at the same time, of efficiency in any machine,

the more do we admire the ingenuity of the mind which has designed and fitted together its various parts.

The effect is somewhat the same, and yet it must be confessed somewhat different, when we contemplate the works of nature. Let us mark in what the distinction consists. When we study any department of the physical world, we cannot fail to see that the results are all brought about by the employment of special arrangements; and we can scarcely fail to experience a sentiment of wonder and admiration in tracing the frequently minute and even occasionally bewildering combinations which lead to the desired results. The anatomical, physiological, and histological study of the human frame will illustrate what we have intended here to express. Take a simple illustration, suggested by the nature of our subject. The sense of vision is dependent on rhythmical movements exerted by the sun on an elastic medium which pervades the farthest bounds of the physical creation. How much does it fill us with wonder when we realise that a mighty agency of this kind, which is the chief source which regulates the purely mechanical forces at work in the world, should at the same time be found to be so contrived and constituted as to act both pleasantly and dexterously on the most perfect and the most delicate organ of the body! And yet so it is; the action and efficiency of the eye are dependent on the play of this mighty cosmical agent, whose velocity and power almost transcend our powers of calculation. Have we in this and in similar arrangements any evidence of design existing in the world? This is the question of supposed difficulty.

The various agencies in nature which work so wondrously in harmony, differ from artificial productions in this respect, that while we have witnessed the formation of machinery of all kinds, we have never seen the hand which is capable of forming the mighty works of nature. We see simply that these exist, and we see the purposes which they subserve. The question, however, of their creation, its time and its manner, involves elements so remote from human experience,

and so far beyond the reach of our limited faculties, that perhaps it should not be considered surprising that some minds are found unable to accept the doctrine of the creation of the world in any form, and that, consequently, they are impelled to a belief in the eternity of matter and in the working of an eternal blind force; resorting to this, apparently, in their difficulties as a temporary refuge—a temporary and insufficient refuge truly; for who can fail to ask himself this question: Can blind force have produced this finished work? Can the unconscious have evolved the conscious? Can matter have developed mind and the reasoning power?

It may be from mental peculiarities, or it may be from educational habits, but certain it is that we occasionally find persons professing to be satisfied with this position. The hand of the mason becomes hard by the handling of stones, and we sometimes find that they who confine themselves to one side of nature, lose the power of realising the force of great moral and metaphysical truths. With them seeing alone is believing, and apparently because they are constantly dealing with matter, they come to regard it as the sole entity and the sufficient cause of all phenomena. Sometimes such persons, discovering that the active properties of matter indicate something of a spiritual character, come to believe in the power of nature as an eternal force, existing they know not how—possessing no intelligence, but yet, strange to say, producing intelligent beings, and a whole, well-furnished, and beautiful world, fitted for the wants of its various inhabitants.

Thus there are two positions taken by two classes of men. Let us, as siding with those who believe that a supreme intelligent Being is the framer and conductor of nature's laws, consider this new theory of creation which has received the name of Darwinism.

Let it first, however, be premised and clearly admitted that no physical theory has yet been proposed to explain the phenomena of vegetable and animal life and organisation, and that we are accordingly compelled to receive the appear-

ance of living organisms as an unexplained and exceedingly mysterious phenomenon.

Starting, then, with this admission of ignorance and wonder, our experience furnishes us with this one simple fact, that the various animals of which we have knowledge are seen to spring from parents resembling themselves, like producing like. We do not know why this is the case. We only know that it is so. A double puzzle therefore presents itself. First, how are we to account for the existence of animal life at all? and, second, how are we to account for so vast a variety and such a constant succession of different types as we find to exist, and to have existed, in the past and present of our planet? Animals differing endlessly in size, form, habits, and faculties. Did these spring into existence with their present organs and endowments as the product of a sudden mysterious creative power? or has that Power which sustains all nature's laws wrought out this part of His plan by a slow and gradual and, as it would seem to some persons, an easy process of evolution? This has become one of the great problems of the day. A problem which has been suggested by various writers at different times, but which the author of the "Vestiges of Creation" and Messrs. Wallace and Darwin have in our day with special ability laid before us to be solved.

While direct evidence in such a case is impossible, we must yet admit that a sufficiently extensive collection of facts, geological and anatomical, may by-and-by bring the question to such a bearing that we shall be able to affirm with some precision how far the theory is a sound one; and, perhaps, also how far it is fanciful and extravagant.

Leaving the problem to be wrought out by the elaborate and patient labours of scientific investigators, we may in the meantime make some remarks on the bearing which the theory has on the question of design. And thereafter we may state the difficulties which seem to beset the theory.

Suppose, then, in the first place, that facts should so

accumulate as to force us to the conclusion that the various existing animal tribes were the result of a process of development conducted over countless ages; and that proofs were laid before us that man is but the top and crowning part of a fabric which, by minute yet distinguishable steps, has ascended from the humblest creatures possessing life and consciousness. If this position should be established, how, we ask, should such a revelation affect the principles of natural theology? Should it shake or in any way invalidate the position we have assumed? viz. that in every case of complex arrangement we are entitled, nay, compelled, to judge of design and object by *the results*, irrespective of the means employed in bringing them about. Is this a true position? or is it more correct to say the results which we observe in the field of nature are indeed great and marvellous, but the means employed have been slow and devoid of startling interest, and therefore we cannot justly view these results as affording evidence of a great designing mind? This, it seems to us, would be a very incorrect conclusion to arrive at; for in all human affairs we are so constituted that the simpler the means employed to attain any object the more are we justified in admiring the skill which, by seemingly simple means, has produced results which are both curious and valuable.

We feel this to be a great and important axiom applicable to natural theology, and one which cannot be assailed, namely, that in every case we are entitled to look at the finished work, and, judging from it, to say, here is a work of utility and skill! here is a proof of ingenuity and wisdom! irrespective of all inquiry into the ways and means by which the work has been accomplished.

But, again, we would inquire, and the inquiry is a very natural one: Suppose a process of gradual development from humbler to nobler forms of life were proved, are the means really so despicable and unworthy of notice as we have been assuming them to be? We cannot admit this to be the case.

We think it may be urged, not only that the results are great, but that the steps also, as showing a steady onward progress from chaos to order, from humbler to higher, from brutish to human, are no less to be admired, affording, as they do, proofs of a beneficent and unswerving purpose. By reason of that character of combined slowness and sureness which marks them, may we not say they all the more emphatically stamp with a Divine dignity the majestic tread of that great Being with whom time and space are as nothing, and who in the accomplishment of His designs hastens not as man would hasten, because He knows and has planned not only the end, but each step and stage of the progress.

Feeling this, we have no aversion to the theory of development on the ground that it really weakens the theistic argument. We experience, however, difficulties in accepting Darwin's views as affording a sufficient explanation of the appearance of the various animal tribes which people and have peopled the earth. His seems a theory rather of destruction than of creation. He and Mr. Wallace show how in this world the strong and well-equipped will flourish, while the weaker and more stolid will go to the wall. This is a law which has long been familiar to naturalists, and especially to those who have endeavoured permanently to improve the herbage of their lands. In every variety of soil the herbage which is best suited to the situation takes fast root, and shoulders out the plants which are less fitted for the particular soil and climate.

Messrs. Wallace and Darwin have with great ingenuity exhibited to us how extensively this principle operates in the animal kingdom; and, pushing their argument to its furthest limits, they have proved that the survivance of the fittest and the known transmission of hereditary properties must result in the gradual establishment everywhere of a breed of animals possessing longer and stronger organs of defence and offence, longer and stronger bills, jaws, claws, legs, stings, wings, etc. And to this extent most men will accept the theory.

But while we admit this, it does not seem to us that these writers and naturalists have suggested any principle to explain the appearance of animals with new organs external and internal, and especially the appearance of different organs of sense. This has always appeared to us the weak point in the theory; for, unless we admit the principle of a creative and, we may say, inventive power, the theory, wide though its operations may extend, fails entirely to account for the different well-marked types of animal life. Geology has exposed to us a vast variety of plants and animals previously unknown. Some of these surprise us by presenting forms strikingly in contrast with those with which we have been acquainted; others astonish us nearly as much by their combined points of similarity and divergence. Facts so curious, coming thick upon scientific men, could scarcely fail to encourage the idea of a continuity in the chain of living beings, and to suggest the inference that, if the links could be all gathered up and arranged, while the most striking varieties and contrasts might be discovered to exist when we compared distant portions of such a chain, yet those contrasts might be expected to dwindle down to disparities almost imperceptible when we examined the *nearer* links.

If such a chain, or if a series of such chains, were proved to exist, such a fact would doubtless go far to establish, at least, a much more intimate connection between animals of similar type than has generally been supposed to exist. As yet, however, we find the chains very far from such completeness, and even the most zealous promoters of the theory admit that the blanks may never be filled up. In the meantime, it cannot be denied that many circumstances, both general and specific, serve to give a strong show of probability to the theory, so long as it is not pushed beyond the limits of facts and fair inferences.

Thus we must all admit the fact of a general homology of organs throughout nearly all vertebrate animals; and this truth receives a curious confirmation and extension from

the study of the rudimentary or aborted organs which exist in man and in various other animals, and we naturally put the question: Why should man possess muscles and organs which are useful to the lower vertebrate animals, but which are entirely useless to him in their rudimentary form? Why should he possess, for instance, muscles for moving the skin, the scalp, the ears, like the humble herbivora, but which the higher animal does not require to use. Why should he possess in an aborted state the rudiments of a nictating membrane which is usefully employed by birds, and by some reptiles and fishes? The vermiform appendage of the cæcum has greatly puzzled physiologists. In man it is small, and not only apparently of no use, it is sometimes positively dangerous. In the lower animals it is very much larger, and may subserve some useful ends. We may increase our list of anomalies by referring to the caudal appendage which Lord Monboddo concluded man at one time to have possessed. The tail theory has certainly received some support from recent anatomical examinations, which not only bring to light the probable aborted rudiments of a prehistoric tail, but also the forms of rudimentary muscles capable doubtless at that time of giving to it a graceful movement. Circumstances such as these startle us by suggesting the possibility of almost incredible transformations.

Again, it is known that the cultivation of plants, and the domestication and breeding of animals, afford many proofs of what may be done to obtain variety of form and habit in the animal and vegetable kingdoms; and the question becomes a highly important one in more than one respect. How far is it possible for external circumstances to effect change of form? *What is the limit?*

While, however, there are many things to commend this theory to the careful consideration of men of science, yet it involves difficulties which come very soon to the surface, and which have certainly refused to accommodate themselves to any principle of natural development hitherto proposed.

Animals formed on most dissimilar plans stare us in the face and decline affiliation with other classes. New forms, new organs, protest against the law of forced affinity, and effectually bar the theory, unless it can relax its hard and fast doctrine, and admit the existence of an inventive or designing principle in creation. Darwin, by leading us too much to surmise that all change and progress are the result rather of chance than of a far-seeing wisdom, has, we think, not only deprived his theory of much of its interest, but also of much of its rationality. Without the element of intelligence and design, the theory seems to us neither to satisfy the conditions observed, nor to satisfy the mind of man which seeks a cause for everything that is great or curious.

Stronger beaks and stronger claws are manifestly useful in the battle of life, but they involve no new idea. The introduction of a new organ involves a new idea—in other words, mind—and the principle of design. But eyes, say the advanced modern school, may be supposed to start as mere differentiations in the cells of the cuticle. The heat and the light may produce a chemical change, and something like pigment cells may be the result; and these again may be differentiated gradually into eyes. We suspect that without mind, eyes are not to be made on these terms. If they are so easily produced, why should eyes not be scattered broadcast over all parts of the body? Why should they be differentiated only at two points.

Leaving eyes to speak for themselves, let us, to illustrate our meaning, take the humblest instance of design we can think of. Can chance and the survivance of the fittest, account for the formation of the wax in the ear. How does wax chance to be secreted at the precise opening into the ear? Then, why is this substance not edible? why, on the contrary, is it extremely bitter, poisonous, and offensive to insect sensibilities? Again, are all *waxless* branches of the human family extinguished because of their waxlessness? and has the present branch survived simply by virtue of

having this curious substance in the ear? As we understand it, this is the argument by which the evolutionists account for wax, and for everything else that is useful. They see no marks of wisdom in the placing of wax of this sort just in that part of the body where alone it can be of any service. Theirs, it seems to us, is a negative theory; it accounts for nothing new, not even for the existence of this very trivial, but, at the same time, refined last touch of a master's hand.

We do not know whether Mr. Darwin admits the operation of a designing principle in nature. Naturalists very properly have a great aversion to recognise a supernatural element as operating in the world. Let us, therefore, bestow a little reflection on what is usually meant by the supernatural, as distinguished from the natural.

We think we have already remarked that, in surveying the wide field of nature, we find ourselves at innumerable points compelled to admit the agency of *the unknown:* and to many, if not to most men, this naturally suggests what is called the supernatural. But while this is the tendency with many, we find in other minds just as strong a natural disinclination to admit any agency whatever except that of matter. There seems to us to be an error on both sides. Men of science generally deny the possibility of any change in the laws of nature. But even these persons, when their attention is directed to certain phenomena, admit that they find it impossible to declare what the laws of nature or operative principles are which regulate these phenomena. This is eminently the case when we consider the phenomena of vital action and the growth of animal organisms. In all such phenomena, whether they seem normal or exceptional, the *known laws of matter* afford us no explanation.

Let us, therefore, now consider what is usually meant when we speak of the supernatural. The writer is as averse to the use of the word supernatural as the materialist or any other man can be. The word seems to him to be an ill-

chosen word, and one which, in the way it is usually employed, is sure to mislead. They who believe that the laws of the physical world are sustained by the power of Deity, must, in order to be consistent, regard the word supernatural, as it is usually applied, to be a word with a false meaning attached to it, because it implies that the *ordinary laws of nature* are conducted irrespective of Divine power, while the rarer or more complex or less thoroughly understood phenomena require Divine interposition to account for them. This is a habit of thinking and speaking which is too common, but which, nevertheless, is to be condemned as glaringly incorrect; for the man who believes in a supreme Creator and Governor of the world must, to be consistent, believe that all nature's laws, and all the powers and properties of matter, are both established and sustained by Him. No doubt there is a striking difference observed in reference to the two separate kingdoms of nature—the organic and the inorganic. The simplest and the grandest of the laws of inorganic nature is the force of gravity, or that power which binds the universe together in systems and in masses. This majestic power, as we have already remarked, is comparatively simple in its laws. They have been subjected to mathematical calculation; they are well known; and they never vary.

In striking contrast with this simplicity and rigidity we are naturally led to observe the laws regulating the growth and development of animal organisms: these, unlike gravity, cannot be reduced to any fixed formula, much less can they be explained. We may say that, in a sort, we know the nature of the action which draws the earth towards the sun; but we know nothing of the physical action which out of cells or molecular matter produces heads, and hearts, and legs, and arms. From this circumstance, we repeat, we are, as by a sort of necessity, compelled to attribute the creation of animal organisms to an unknown cause, and thus by an easy step to the supreme Cause; and we are right in doing so.

We are, however, evidently wrong in judging differently with reference to the simpler phenomena of nature. The law of gravity is quite as marvellous and unaccountable by natural means as the phenomena of animal life. No philosopher has yet attempted to account for the existence of the primary laws and powers of nature. *There is nothing discoverable in matter that can account for the existence of physical power.* This is admitted by all philosophers, whether Christian or atheistic. Such being the case, no alternative remains but either to take the facts, as the materialist does, without explanation, or to ascribe them all, without exception, to the operation of the supreme spiritual Cause. The one is a negation, or suspension of judgment, the other is a judgment formed on the conclusions of human reason. The person then who holds the latter opinion should, in all nature's phenomena and working, recognise nothing as supernatural, but all as strictly natural though Divine; for the phenomena of this world, whether they be simple or complex, regular or apparently abnormal, are, according to the theistic theory, but the expression of the will and power of that great Being in whom, according to St. Paul, we live and move and have our being.

This is the doctrine of Reid, Stewart, Brown, Hamilton, and of British philosophers generally. It is only to be regretted that in treating of practical questions they frequently abandon the position, and thereby involve the subject in contradictions.

The man of science does not know the ultimate cause even of the simplest of nature's phenomena, such as gravity; still less can he explain the most secret and mysterious of her workings, which the formation of living creatures unquestionably is. He naturally looks at external results; and he argues thus. Because this species or variety of animal happens to possess a longer horn, or a larger head, it stands its ground, while its less favoured congeners perish. He is satisfied with the annunciation of this law of nature.

The moralist also acknowledges the existence of this law, but his mind more naturally reverts to the deeper mystery of creation; and whether he contemplates the formation of the fœtus in the mother's womb, with organs corresponding strictly with those of the parent's, or with organs differing more or less in length, strength, size, or even in form and type, and by this promising to raise the possessor as a living creature to the enjoyment of higher powers, he cannot separate the cases so as to make them fall under different categories; they appear to him to be both equally mysterious and unaccountable; they both afford gratifying proof of progress, in different stages and degrees; they both are undoubtedly the result of a law of nature, if we could properly understand it; they both indicate design; and they both alike transcend the reach of mere physical science to explain them. If we do not see this, the loss to us seems great, for we thereby miss one of the higher lessons of nature's teaching.

PART II.

PHYSICAL LAWS AND PHYSICAL ORGANS.

CHAPTER VII.

SOUND.

HUMAN KNOWLEDGE—ITS NATURE—ITS LIMITATION—INORGANIC AGENCIES THE MEDIA OF OUR SENSE-KNOWLEDGE—SOUND—ATMOSPHERIC ELASTICITY—TENSION—WAVES OF CONDENSATION—OF RARIFICATION—PROPAGATION AND DIFFUSION OF SOUND—DR. YOUNG'S EXPERIMENTS.

FROM this *Second Part* we exclude all metaphysical reflections on the nature and cause of phenomena. Our aim here is to gather together the more important facts connected with that part of the mechanism of the world which has reference to the senses. Some readers may consider this the more important part of the volume, others may pass it over altogether. It is evident that the senses cannot be understood without a certain knowledge of the physical and physiological laws on which they are dependent; therefore this and the following Part have their place in the volume. It is from a want of such knowledge that writers on the phenomena of the senses, so often maunder about *difficulties* and *impossibilities* which they would find removed by a very moderate amount of careful physical study.

The reader will, we hope, find the summary of physical information given in Parts II. and III. sufficient for all the purposes we have in view. Along with much that is necessarily trite and well known, he will discover several principles announced which may throw some new light on the theory of vision.

Our subject is ONE, but it divides into many branches. Thus it begins naturally with matter. Then it passes to the consideration of animal life and consciousness. This leads us,

in the third place, either to the examination of that outer world of which we are conscious—Natural Science, or to the examination of what is directly furnished to the mind—The Sensations, and the other mental phenomena connected with them—Psychology. From this point mental philosophy starts.

We judge it expedient in the Second and Third Parts to mass together all that has reference to the physics and physiology of the senses, in order that we may have the more freedom in the latter half of the volume to examine into the philosophy of the subject.

The belief in man's double nature, the physical and the spiritual, must have been very early implanted in the human mind, for we know not an instance of any nation of antiquity, barbarian or civilized, in which it did not exist as an influential faith. We believe that this conviction arises within us as a human instinct, and that it becomes afterwards confirmed and established as a necessary deduction of reason. Throughout this volume we assume the theory of mind and body to be well founded, and we give our reasons for doing so.

Connected with the subject of human knowledge, we can conceive the mind of man under various possible circumstances. Thus we can conceive that it might have been created and put in connection with inorganic amorphous matter, and that through the movements and vibrations thereof it might have been left to acquire knowledge of a certain range. Or, on the other hand, we can conceive that, unfettered by any material connection, the mind might have been permitted to enjoy a direct or intuitional perception of the existence, thoughts, and feelings of other beings like itself. Neither of these conditions is ours. The sentient principle is closely connected with a lithe, moving, highly organized framework, and is allowed intimation of the world's existence through slender cords and filaments, whose movements or affections are made to impress the mind in peculiar ways. The mind has thus no direct intercourse with the world.

Even the materialist will admit this; for as the brain is the sole seat of sensation, its affections are caused not by direct contact with the world, but only by the action of those nervous cords and fibrils of which we shall have more to say by-and-by.

We all know the illustration which Plato gives of human knowledge. We can scarcely say that it is fanciful, and we cannot allege that it is exaggerated. He compares the soul within the body to a person in a dark cave, whose face is turned away from the light streaming in from the entrance, and who perceives, consequently, not external objects themselves, but merely their shadows thrown upon the wall of the cave.

The study of the nature of man's knowledge acquired through the senses must impress every intelligent student with a conviction of the indirect and limited nature of that knowledge. We see not the causes of things; we see not their essential nature; we learn only certain of their powers and modes of acting, and, as a principal element, the form and structure which they assume.

But though man's knowledge is limited, yet we have never seen any ground stated, either by metaphysicians or idealists, which should lead us to believe that it is other than reliable and trustworthy knowledge so far as it goes. On the contrary, in order that it may be precise, and that living creatures, and especially that man, the most favoured of nature's children, may be enabled to extend his observations and thus exercise a wider intelligence, he is furnished with special and extremely complex organs of sense, suited at once to minister to his enjoyments and to furnish him with materials profitably to occupy his inquiring nature.

In connection with the subject of the special organs of sense, we are necessarily called to examine those inorganic agencies which exist in nature, and which are designed to act on those organs. On the threshold of this study we can scarcely fail to observe that frequently an important portion

of nature's external arrangements are capable of discharging many and very different offices. Thus, for instance, the atmosphere, by its chemical properties, as we know, plays an all-important part in connection with animal and vegetable life; by its weight and buoyancy, at the same time, it sustains the clouds; and by its currents it carries them inland to fertilise regions remote from moisture. It equalises temperature; it originates currents in the ocean; and it wafts commerce over the globe; and, then over and above these and many other equally important functions, by its lightness, tension, and elasticity it is the chief medium for effecting intercourse between mind and mind, and between the mind and the outer world.

The luminiferous medium, again, which pervades every portion of our universe, and which, as the medium of vision, reveals to us the existence of distant suns and systems, at the same time acts on our planet as the leading power in the growth of all living organisms.

It is to the physical properties and movements of these outward agencies that we have now to direct our attention; and there is, as we have said, a special interest in noting how the movements of the great and majestic elements of nature are made to minister to the intellectual wants and enjoyments of man and the lower creatures. Were it not for this plastic and versatile character in nature, how different would be the whole scheme of animal life. Without further preface we shall enter upon this branch of the subject, and first, regarding SOUND.

1. Sound is produced and propagated by the vibration of any elastic medium, whether solid, liquid, or aeriform. But as it is conveyed to our ears and becomes an object of sense solely through the air, we shall confine our attention to its production and propagation in this medium.

2. Though it is pretty generally known that sound is the result of a vibration of the air, yet we believe very few clearly apprehend that the investigation of the laws of these vibra-

tions involves the most intricate problems of fluxions, and that in attempting to conceive their nature, even the illustrious Newton failed. It should, however, enhance our interest in the subject to know that, difficult as it is to comprehend or to describe these vibrations, yet upon our power of regulating their form, rapidity, size, and order of succession, depends the exercise of the gift of speech, and our possession of the universally enjoyed luxury of music. All we shall attempt in these pages is to embody the leading results of such investigations as may be explained without unreasonably taxing the reader's patience.

3. There may be felt some difficulty even in imagining the nature of such a vibration as that producing sound, excited by such feeble means—the tuck of a drum, the compressed breathing through a tube—yet carried through the air so far, so clear, and with such surprising velocity. We wave the hand, and find how free and unresisting the air is; scarcely do we perceive any obstruction. We feel thence a difficulty in conceiving how so yielding a medium can produce effects so various and distinctive as those characterizing sound; and how it can carry it with such velocity.

4. As we walk the deserted streets, every step or cough is echoed to our ear: we strike our stick upon the pavement, how sharp and hard and immediate is the reply echoed from the opposite houses! and how distinctly does it whistle as reflected from each iron rail that fences the areas! Try the echo from the side of a high wall, say one hundred steps in front; shout, clap the hands, laugh, whistle—how promptly and truly is each different sound retorted! The same soft yielding air carries back alike the prolonged notes of the French horn and the harshest and most discordant notes. It is at first a difficult problem to apprehend how so slight an impulse upon so yielding a medium can produce the sharp and far-spread effect. It seems as if the air were almost of metallic solidity. Let us proceed briefly, but with some little method, to examine the cause of this.

5. The atmosphere, considered simply as an aerial body without reference to its chemical constitution, may be described as consisting of an infinity of atoms, capable of moving freely amongst each other, and which are held separate by virtue of a law of mutual repulsion, each atom repelling its neighbours, and tending to fly further asunder.[1] It is this repulsive tendency that constitutes the elasticity of the air and of all other gaseous bodies. Let us attend now to an influence counteracting this principle of repulsion.

6. The atoms of the air, though individually light, yet possess a definite weight, and are drawn down towards the earth by the influence of attraction: one hundred cubic inches of air at the sea level have been found to weigh about thirty-one grains, and a cubic foot will therefore weigh above one ounce. The vast accumulation of these atoms, therefore, forming the atmosphere, by their aggregate weight necessarily compresses the lower strata of the air, and forces its atoms into closer proximity, though not into actual contact. The *elasticity* and *weight* of the atmosphere at any given line of elevation are thus in equipoise, and the one affords a just measure of the other. It is a law of gaseous bodies, that unless something intervene to affect the elasticity, the density increases in the ratio of the pressure; that is to say, double, treble, quadruple the quantity of the gaseous body will exist compressed in a given space when it is subjected to double, treble, or quadruple the pressure; and the word pressure thus becomes just another expression for the elasticity of the gaseous body. This law holds good until the atoms are forced into such close proximity that the body, losing its gaseous form, becomes condensed into a solid, which has been effected with a great variety of gases.

7. The weight of the atmosphere at the level of the sea

[1] Whether this repulsion is a natural and constant property of the atoms of bodies in their aerial or gaseous state, or whether the repulsion is due, as has recently been suggested, to the vibratory action of the ethereal medium, we need not here inquire. We use the term repulsion as expressing the principle most generally believed to exist, and thus most intelligible to the reader.

is sufficient to support a column of mercury varying from twenty-eight to thirty-one inches—the mean of which is equivalent to somewhat about $14\frac{1}{2}$ lbs. of pressure on every square inch of surface, and this is, therefore, the average measure of the air's elasticity. The knowledge of this extraordinary amount of pressure or tension leads us an important step towards understanding the possibility of sonorous vibrations, and the cause of their extreme rapidity.

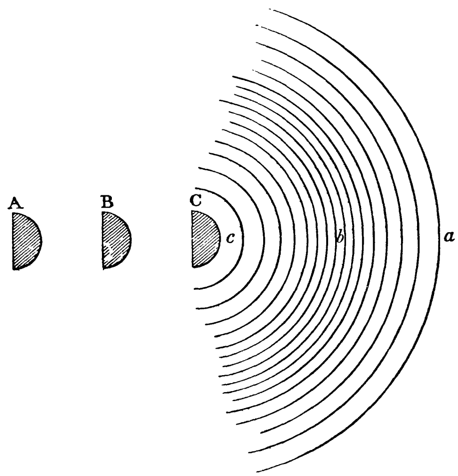
8. It is not every disturbance in the air's density that produces sound: the condensation or rarefaction implied in the fiercest winds produces no sound. Winds may be compared to ocean-streams, for by them a mass of air with its atoms is carried forward and swept over the earth's surface. In sonorous vibrations there is no transportation of atoms, no flowing of a mass of air in a given direction. Even when the air is pervaded by the most powerful sounds, such for instance as exist in a concert room, no motion is perceived in the dust that may happen to float in it, nor are the vibrations detected by our nerves of touch, unless the occasional beat of the drum or a note from some of the more powerful wind instruments, excites a sympathetic tremor in the floor or in any piece of furniture standing near.

9. Sound is produced by a succession of quick, minute condensations and rarefactions in the air; and these must follow each other with a certain velocity in order to excite that sensation. The term a *shock*, *stroke*, *thrill*, or *tremor*, may perhaps best express the nature of the effect on the air.

10. We may thus describe the nature of these waves of condensation and rarefaction which constitute sonorous aerial vibration. When a sharp stroke is given to the air, the molecules, like all other bodies possessing weight, are driven forward, and they would impinge on the neighbouring molecules were it not for the repulsion existing between them. This repulsion, then, causes the neighbouring molecules to retire as if they had been struck by the molecules originally impressed with motion. In other words, the first set of mole-

cules struck, deliver over their motion and force to a second spherical film of molecules; and these second molecules hand over their motion and momentum to a film beyond, and so onward and outward, in consecutive circles, the impulse is transmitted at the rate of 1125 feet per second, as represented in the figure.

Fig. 1.



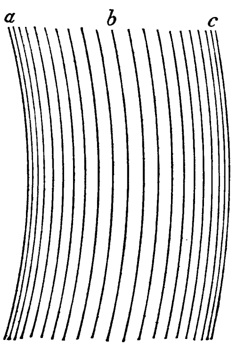
11. One stroke of this kind given to the air would not probably be perceived as a sound; but a succession of such strokes produces an audible note, and the nature of the note depends on the rapidity with which the strokes succeed each other. This we may easily prove. Draw an ivory paper-cutter slowly across a rutted or groved surface, and a certain note is produced; draw it with double the velocity, and we shall obtain the next higher octave of that note. The note, therefore, depends on the number of strokes per second given to the air or to any elastic body.

12. The impulse described produces in the air a wave of condensation; and as we have said that it is propagated at the average rate of 1125 feet in a second, and as it requires at least sixty-four such waves in a second to produce a clear sonorous sound, the depth or thickness of such a wave of

condensation will be about $17\frac{1}{2}$ feet. This is one of the gravest notes the human ear perceives. The C of the open organ pipe thirty-two feet long produces it. The lowest note, A, of the seven-octave piano, produces about thirty-six double vibrations, and the highest, A, of the treble 5120 such double waves per second. The thickness of the waves of the lowest note will be upwards of twenty-one feet, and of the highest note about $2\frac{1}{2}$ inches. Sound is generally excited in the air, not by a succession of such waves of condensation as we have described, but by alternate waves of condensation and rarefaction.

13. The wave of rarefaction is produced, not by a stroke given to the air, but by a rapid partial vacuum produced by the backward movement of the string or other vibrating body. This rapid retreat of the string gives room for the expansion of a film of air in contact with it, the atoms of this film being relieved of pressure on the side of the retiring body, while they are urged by the repulsion of their neighbours on the further side, follow the retiring spring, and relieve the pressure of their neighbours, which are consequently urged towards the vacuum by the elasticity or pressure of those lying beyond, and so by the motion *inwards* of the atoms of air, a movement or disturbance is propagated *outwards* from the centre of disturbance. The extent of rarefaction and of the motion of the atoms of the stratum in contact with the retiring body varies with the velocity of that body, and this varying velocity is faithfully communicated from film to film, and forms a wave of rarefaction, such as we here present.

Fig. 2.

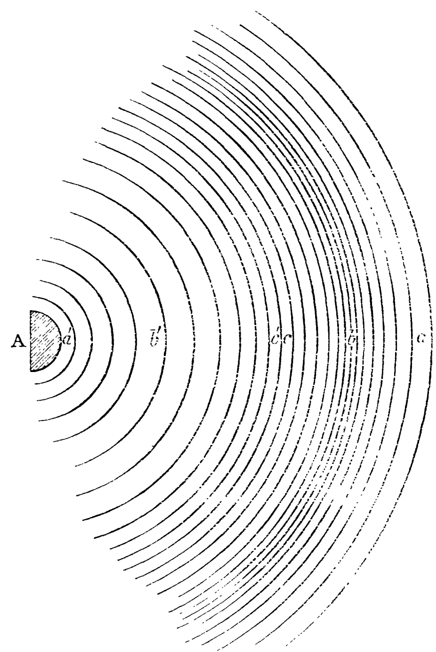


14. A rapid succession of such waves, at the rate of thirty-two waves of each kind in a second, produces the lowest or gravest sounds which most ears can appreciate as a musical

note, or continuous sound: all motions slower than this become insensible to the organs of hearing. If they are perceived at all, it is not as sound, but as vibration.

15. The propagation of the wave of rarefaction being due to the same law of elasticity as the propagation of the wave of condensation, the two waves travel with like velocity, and they will be of like thickness throughout. These two waves expanding spherically would, supposing no more waves to follow,

Fig. 3.



continue to travel outward from the centre with undiminished velocity, and retaining their original thickness, the motion of the individual atoms or molecules of air set in motion only becoming more and more feeble as the waves expand from the centre. The figure represents the combined waves: the outer circles belong to the wave of condensation, the inner ones to the wave of rarefaction. The outward motion of sound would continue till stifled by the imperfect elasticity of

the air, or reduced in intensity by expansion so as to become inaudible. From the circumstance of the equal velocity of all sound, whatever its pitch or intensity, and the consequence necessarily flowing from it, that the thickness of the wave continues unaltered throughout its course, we derive the important advantage that the notes of speech and of music reach the ear unaltered in pitch and in time, whatever the distance of the auditor may be. Were it not for this law, the air would be unserviceable as a medium of sound. Music heard from a distance would become a mere confusion of sounds, and speech would be a species of inarticulate jabber —a misfortune greatly more serious than that to be explained in optics as resulting from chromatic and spherical aberration.

16. The explanations given will afford answers to questions which may naturally arise, such as these :—To what is owing this great velocity of sound, the originating motion being frequently so trifling? Why does the air, once impressed with vibration, not continue to vibrate like a bar of iron, or the string of a musical instrument? Why does the sound, once excited, vanish instantly with the exciting cause? How is it that the waves of rarefaction are propagated in the same direction as those of condensation?

17. The term wave, or undulation, or pulse, is thus merely an expression for a certain extent of air under a state of finely graduated condensation and rarefaction. Or, to express it by describing the cause instead of the effect, a wave is an extent of air, the atoms of which are all in motion at once, in concentric spheres, the motion being either in a direction away from the centre, which marks the wave of condensation, or in a direction towards the centre, which marks the wave of rarefaction. And two things are to be observed: first, that no two spheres or films are in equal velocity of motion at the same instant of time; those in the centre of the waves possess the greatest motion, and those at the extremes of the waves the least; second, that these minute movements of the

atoms, whether backwards or forwards, are ever communicating their movements to films outwards from the centre, and doing so with amazing rapidity. It is certainly no easy matter to form a distinct conception of such a thing as this, where all is motion, and where, at the same time, every part is undergoing a constant and instant change. Such a state of movements is expressed as a *flowing quantity*, and it is the province of fluxions to investigate it minutely.

18. Various phenomena visible to the eye may be referred to as illustrating the propagation of sound: thus the concentric waves which so beautifully expand outwards when a pebble is dropped into the quiet pool is one illustration. Another example of undulation is produced by waving a carpet or table-cloth close to the ground—a mode of exciting storms which is instructive to the philosopher, as bringing close to the eye a really scientific representation of how ocean waves progress.

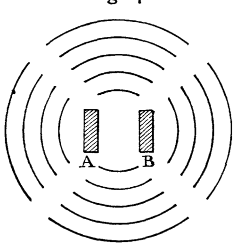
19. Another illustration of vibration is the wave that runs along a stretched rope when sharply struck by a stick. Though in a short string nothing is seen to result but a steady vibration throughout the string, yet in a long cord of considerable thickness the vibration assumes the aspect of a wave rapidly travelling along; and if the cord were of infinite length the wave would not return. In a long rope, fixed at both ends, the eye has time to follow the wave, and can observe that so soon as it has reached the far end, in a manner analogous to an echo, it rapidly returns, and continues to run backwards and forwards till the imperfect elasticity of the cord destroys it.

20. It is usually said that aerial vibrations diverge equally and in all directions, as from a centre. That this is only a tendency, and not an invariable result, is evident, else why should the voice be best heard when the mouth of the speaker is directed towards the hearer, or how otherwise should a speaking trumpet have the power of concentrating the sound and directing it with effect in the desired direction? and

why, again, should sound be obstructed by the interposition of a wall or rock, but fall upon the ear so soon as we clear the obstruction? or how should the chime of a distant bell swell and die away with the breeze that carries it?

A proof that the vibrations are urged in the first instance in the direction of the impulse, was discovered by the celebrated Dr. Young, and which is thus described by Sir John Herschel. "If the axis of the tuning-fork be held upright about a foot from the ear [we find it to answer better much closer], and it be turned round this axis while vibrating; at every quarter revolution the sound will become so faint as scarcely to be heard, while in the intermediate axis or rotation it is heard clear and strong. The audible situations lie in lines perpendicular and parallel to the flat faces of the fork, the inaudible at 45° inclined to them. The two branches of a tuning-fork vibrate by alternately approaching and receding from each other, and the direction of greatest intensity of sound will be as exhibited below, A B being the ends of the fork. In the intermediate directions the air seems not at all disturbed. The pulsations, however, expand as they advance, and gradually mingle, so that at a little greater distance they are equally perceptible in all directions.

Fig. 4.



21. We may remark that sonorous waves, with the simplicity of shape we described in explaining the waves of condensation and rarefaction, are of extremely rare occurrence. The strings of all musical instruments are placed in connection with the sonorous body of the instrument, and it is chiefly, if not entirely, in consequence of the vibrations which the strings impart to the extended body of the instrument that we are indebted to the production of their sound. That these vibrations are exceedingly various and complicated the experiments of Savart abundantly prove; and the nature of the over-tones and harmonic notes thus

produced has since been thoroughly studied and explained by Helmholtz. In every stringed instrument the object is to bring into vibration the extended surface of wood or other material of which the instrument is composed. It is thus that a variety of harmonic tones are produced, on which the volume and richness of the instrument mainly depend. The sound produced by the strings, unless in connection with an extended sonorous body, is feeble; but, query! is there any sound whatever produced by a vibrating cord properly insulated? From experiments made by the writer, he is more than doubtful if there is.

CHAPTER VIII.

SOUND (*Continued*).

RANGE OF THE HEARING FACULTY—PITCH AND QUALITY OF SOUND.

22. WE have hitherto considered the simplest form of sound, viz. that resulting from the vibration of a single body producing a definite pitch of sound. The nature of all sonorous waves is physically or organically the same, however much they may vary in the rapidity of their succession. Upon the number of vibrations occurring in a second depends the pitch of sound; the more rapid the succession of vibrations, the higher is the note produced. As all sound, whatever pitch and whatever intensity it may have, travels with the same velocity, it necessarily follows that the thickness of the waves, and the number of them within 1125 feet, will vary according to the note sounded. The highest note audible to the human ear is supposed to be formed by about 9000 vibrations per second. It is well known, however, that there is a difference in the range of sound perceived by different individuals. Dr. Wollaston's attention was drawn to this subject, and he found that some persons, otherwise in no way inclined to deafness, were altogether insensible to very acute sounds, even to such as painfully affected others. One person mentioned by him could just hear a note four octaves above the middle E of the pianoforte, while others had a distinct perception of sounds full two octaves higher. The chirp of a sparrow was about the limits to such defective ears; the cry of the bat is about an octave higher, while that of many insects is probably much

higher, and some of these are doubtless inaudible to the human ear. Dr. Wollaston's sense of hearing was limited to six octaves. The utmost range of human hearing, comprised between the lowest notes of the organ pipe and the highest known cry of insects, seems to be nine octaves. Dr. Wollaston, on this subject, makes the following obervation:—"As there is nothing in the nature of the atmosphere to prevent the existence of vibrations incomparably more frequent than any of which we are conscious, we may imagine that animals like the Grilli (grasshoppers), whose powers appear to commence nearly where ours terminate, may have the faculty of hearing still sharper sounds which we do not know to exist; and that there may be other insects, hearing nothing in common with us, but endowed with a power of exciting, and a sense which perceives vibrations of the same nature indeed as those which constitute our ordinary sounds, but so remote that the animals who perceive them may be said to possess another sense, agreeing with our own solely in the medium by which it is excited."

23. As the pitch of a note depends on the rapidity of vibration, so it is a fact confirmatory of this, that a musical note of higher or lower pitch may be produced by any sufficiently rapid succession of sounds, though these sounds be in themselves quite unmusical. Thus, if a toothed wheel be turned round with sufficient velocity, and a steel spring be made to strike against each tooth as it passes, a musical note is the result, and the pitch of the note may be varied by varying the rapidity of the wheel's revolution: different experiments with the same result may be endlessly made. A familiar variety of the experiment we have seen made by a nurse when wishing to amuse a fretful child; she drew her nail sharply across the texture of a moreen curtain, and thus produced a shrill note which occupied the attention of the child, although it did not philosophise on the cause of the phenomenon. The sound thus simply produced may be varied several octaves by altering the rapidity of the motion,

and by a little practice a simple tune might even be obtained from the curtain. Another example of a musical note, resulting from a quick succession of unmusical sounds, must have been observed by every one when talking or walking in a sufficiently large unfurnished room or passage: a clear high note is heard, which is the result of the reverberation of the sound from the walls, roof, and floor. Small rooms yield an acute sound, and lofty halls and cathedrals return a more solemn note. Each room has, in fact, its fundamental note of resonance, and in many cases it is quite necessary that the speaker should study this in order that by timing the rapidity of his utterance, and regulating the pitch of his voice, he may form with it, if possible, a pleasing harmonic, and not a stifled or grating dissonance while he speaks. This is attended to in intoning the service in Roman Catholic and Episcopal cathedrals. Another instance of the same kind is the sharp whistle returned by the separate bars of a paling: the sound of the heel upon the ground may be a low and dull one, but as it is re-echoed to the ear in quick succession from each rail, it becomes a highly acute sound, as many may have observed.

24. The quality of sound is an entirely different thing from its pitch, and it has, we may say, a variety as infinite as the causes exciting it. Every musical instrument, every animal, every object in nature, has its peculiar quality of voice, and this, where the sound is produced by a living agent, is again further modified by the circumstance of skill in the performer, and by the prevailing sentiment animating the performer at the time. By this variety in note and quality, the practised ear is enabled, on hearing a sound, not only to distinguish the originating cause, but as with the ease of intuition to appreciate the sentiment which calls it forth. Thus all nature speaks a natural language to man's ear—the lash of the sea, the cry of the sea-fowl, the moan of the wind, the distant cry of distress, the watch-dog's honest bark, the voice of friendship, of

pity, of anger, of terror, have each a quality which needs no interpretation. Everything has in fact its distinctive utterance; and events and feelings, though distant and unseen, report themselves to us in strictly appropriate music, and the soul of man is thus bound in inseparable harmony with external nature.

25. Apart from the peculiar note, or succession of notes, uttered by beast, bird, or insect, we have this natural modulation to guide us, and seldom is it that we fail to find the indication even more trustworthy than the articulation of words. Happily for us it is so; thus scarcely may hypocrisy, either in man or beast, put on a feasible counterfeit; an unmistakable something in the tone tells the truth: the voice of honest Iago gives the lie to his words; and flattery alone, or that triple casing of innocence which we find only on the *stage*, or in the poet's page, has power to close the ears against the tones of villany.

26. In order that the reader may clearly understand what we mean by quality as distinguished from pitch, let the different instruments constituting a musical band, repeat in succession the same note, or perform the same air in the same key, and the difference in the character of the sounds will mark what we mean. The same number of vibrations are produced—the waves follow in the same order, have the same size and rapidity of succession, and the musical ear can at once pronounce the notes identical, yet how widely does the quality differ in each. The quality of sound must depend on the composition of the waves as influenced by the extent of the vibrating surface, and principally on the harmonics or over-tones excited by the compound vibrations which exist throughout every fine-toned instrument; and these again depend on distinctions in the form of the instrument and the nature of the material of which it is composed.

CHAPTER IX.

SOUND (*Continued*).

HARMONY—A NOTE—NATURE OF WAVES PRODUCED—TYPES OF WAVES OF EQUAL AND UNEQUAL LENGTHS—IN COMBINATION—CONCORDS—BEATS—NATURAL HARMONICS—SCALES OF INSTRUMENTS WITHOUT FINGER KEYS—THE DIATONIC SCALE.

27. A HIGHER branch of the science of sound now claims our attention, namely, that which treats of the effects produced by two or more sounds of different pitch simultaneously excited. This introduces us to the subject of harmony.

28. Considered physically, when a single pure note is produced, we have to conceive of alternate waves of condensation and rarefaction poured into the ear, and following each other in a steady, unvarying succession, the number of these per second constituting the pitch of the note.

29. The perception of sound is unquestionably due to the rapid movement or vibration given to the extremities of the auditory nerves lying in the fluid contained in the cavities of the bones of the inner ear. The vibration is communicated both through the medium of the small bones, and of the air in the tympanum, or middle-ear. It is certain that the nerves are affected also by a direct vibration of the cranium and bones of the inner ear. There can be no question that the solid bones of the cranium as well as the hollowed bones composing the inner ear, partake of the vibration. This vibration of the bones of the cranium may appear incredible ; but the moment we become acquainted with the molecular structure of matter, and know that its atoms are held,

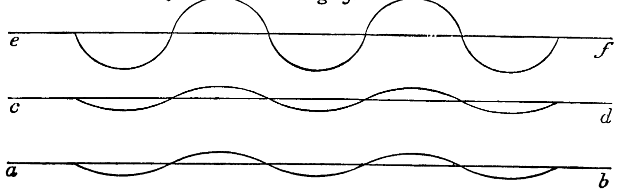
not in contact, but merely towards each other by the simple law of attraction, we see how all matter, even that which is seemingly most solid, must be subject to vibration from every external force, however feeble. We know not a fact more curious than this of the vibration of solids, and an interesting chapter might be written on it.

30. A representation of the state of the air under the influence of sound we have given in Figs. 1, 2, and 3. The type of the waves is, however, usually exhibited by waving lines, as in the following figures, the elevated part representing the wave of condensation, and the depression the wave of rarefaction. The varying height of different parts of the waves above the straight line, or their depression beneath it, marks the extent of density at particular parts of these waves, and is also an index of the velocity of the molecules at the part.

31. Let us now consider the effect of the existence of two waves of sound simultaneously excited. And, first, let them be of the same size, resulting from the notes being in unison. In all such instances of combination, the forces of the waves, and the varying motions of their molecules at the different parts of the two waves, will act and react on one another in conformity with the established laws of dynamics. When the forces act in the same direction they will strengthen, and when they act in contrary directions they will weaken or neutralize each other.

32. Waves of equal length, which result from sounding notes in unison, will either entirely coincide, as is the case

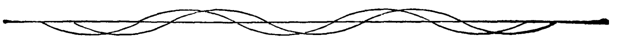
Fig. 5.



with the waves *a b* and *c d*, the joint intensity being represented by the resultant waves *e f*. Or, it may happen

that they are not coincident in place though they are in size (which makes pitch), they will then follow each other, thus:

Fig. 6.



In this latter instance, the coincidences of elevation and depression recur in these combined lines at equal distances, as in each separate line, and therefore the pitch of the resultant note is not altered, though its quality may be.

33. When two notes are very nearly in unison, but not entirely so, or when the number of vibrations of one note does not form a simple multiple of another, these notes when sounded together produce what is called a beat. Thus, if one note vibrates 100, while another note vibrates 101 times in a second, the waves of the last note will evidently gain on the other; and when they reach the opposite phasis, which they will do at the end of half a second, they will act in opposition, and a temporary cessation of sound will be produced; this is represented in Fig. 7. As the waves approach this phasis

Fig. 7.

there will be a gradual weakening of the sound; and as the waves approach coincidence, the sound will swell out. This affords proof of the correctness of the undulatory and dynamical theory of sound, showing that two sounds may either strengthen or neutralize each other; a fact which, without a knowledge of the anatomy of sound, we could not conceive possible, as it is not consistent with experience that two positives should in any instance make a negative. The beat is best exemplified upon the key-organ, by sounding two notes not in perfect unison.

34. Let us next suppose that one note of a certain pitch is sounded, by which a succession of waves is formed in the

atmosphere, at the same time that another note of a higher pitch is producing a succession of waves of double rapidity.

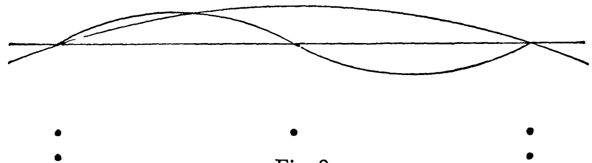


Fig. 8.

The result, it will be seen, must be a perfectly regular and symmetrical succession of waves differing in form from those of either wave singly. The effect on the ear, as also on the eye, will be one of a full and pleasing character. The two notes thus sounded in combination, form the octave of the musical scale, which is the most perfect harmony; indeed the individual notes are so blended that they are lost, and a note which Sir John Herschel describes as being like two sounds, both of the graver pitch, but one of them of a different intensity and quality from the other is produced. This concord may also be represented by the dots under the waving lines.

35. The next most perfect harmony or concord is produced by two notes, the waves of which are in the proportion of two to three. This is, sounding a note and its fifth, as for instance C and G, on the pianoforte, and is called the fifth concord. The waves producing it may be represented by the waving lines of the annexed figure,

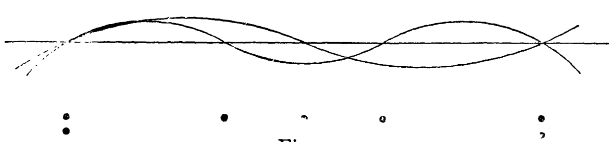
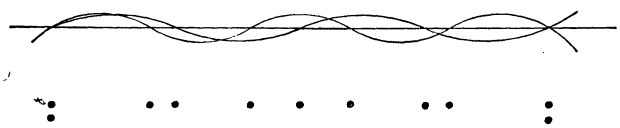


Fig. 9.

or by the dots placed under them, which dots represent the place where the different waves terminate; and the same succession of lines and dots it is evident, as long as these two notes are sounded together, will recur at regular intervals, and in symmetrical order, thus producing a musical tone.

36. Another instance of concords may be given, namely, that of two notes, the waves of the one being four, and those of the other five, which produces what is styled the third concord, because formed by sounding a note and its third,

Fig. 10.



as C and E, G and B, and so on. These combinations of harmonious vibrations may be varied and extended between certain limits.

37. Harmony may therefore be explained as the result of sounding two or more notes, the number of vibration of which are simple multiples of one another, as in the above examples. We shall return to this subject when we come to explain the principles on which the diatonic scale is constructed; but we cannot, in connection with the general subject of hearing, avoid alluding to the singular circumstance, that there exists a very distinctly marked provision in nature for securing harmony. Thus, on throwing into vibration any sonorous body whatever, provided it be not too extended or unshapely—for instance, a stretched cord, a bell, a rod of iron—the vibrations assume a complicated aspect. We may express it by saying that these bodies vibrate in the first instance throughout their entire length, by which they yield their lowest or fundamental note; but at the same time they divide themselves into separate, independent sections, whose vibrations are more rapid, and which are indeed multiples of the larger and slower vibration. Here, then, we have the fundamental note and its natural harmonics sounding at once, and pleasing the ear in a great variety of bodies.

38. We may here illustrate and exhaust all we have to say on this subject. This we shall do by describing the scale of natural harmonics. When a cord is stretched over two fixed points by a sufficient weight, and made to vibrate by the

touch of the finger, or, what is better, by the violin bow, the principal note heard is called the fundamental note of the cord, which is the gravest it is capable of producing under existing circumstances. There are two ways of increasing the acuteness of the note: first, by increasing the tension; and this can be done so as to bring out any variety of higher notes, until the cord snaps. The vibrations increase in velocity according to this invariable rule. The vibrations of the fundamental note being held as 1, *the velocity of the vibrations increase and are as the square root of the tension.* Thus, to obtain *double* the velocity of vibrations, we have to make the tension the square of this—that is to say, *four* times as great; if therefore the tension for the lower note is 10 lbs., the tension for the higher note will require to be 40 lbs. We obtain the third of the fundamental note, which has five vibrations for every four of the fundamental, by increasing the tension to 15·62 lbs., which is the square of 5-4th multiplied into the 10 lbs.; and so on, on the same principle, for higher notes.

39. There is another and simpler way, however, of raising the pitch of the note: it is by shortening the vibrating portion of the cord. By diminishing its length one-half, its vibrations are doubled, and the octave of the fundamental note is produced. By diminishing it to one-third, its vibrations are three times as rapid, and the fifth note above the octave of the diatonic scale is the result. In the same way, one-fourth of the string yields the second octave, one-fifth yields the third to that octave. All these are harmonics of the fundamental note of the string, and combine pleasingly with it when sounded together; and in this way the harmonic triad, the *note* with its *third* and *fifth*, is obtained, which affords the most perfect harmony, and these notes constitute the rudimentary elements of our simpler national airs. We may extend this process of shortening the string by regular steps to a 6th, a 7th, an 8th, a 9th, a 10th, an 11th, a 12th, etc.; and by doing so we obtain the scale of all such wind instruments as consist of only one tube without finger-keys, such as

the French horn, the bugle, the trumpet, etc.; the whole compass of such instruments consisting of their lowest note and its *natural harmonics*.

40. A short pipe will, however, produce few harmonics, and thence the necessity of the long winding pipe employed in these instruments. It is the subdivision into distinct nodes of vibration, into which the long column of air in such pipes is capable of being thrown, that produces the harmonics, or scale, of such instruments; and it is by the force of the air driven in from the lips that the performer is enabled to throw the column into the necessary state of vibration. Practice alone gives him this mastery.

41. The scale of such instruments rises thus :—

C C′ G C″ E G″ B″ flat C‴ D‴ B‴ F‴ G‴ A⁗

42. As we have already said, almost all sonorous bodies besides vibrating throughout their entire surface have a natural tendency to vibrate in separate sections, and thus to produce the fundamental note of the body, with its harmonics. In bells and bars of metal these separate sounds may be easily distinguished. On twanging a metallic wire eight or ten feet in length, the fundamental note is first heard, and as its intensity decreases, one or more of its harmonics will generally be heard to swell out, and even to overpower the fundamental note.

43. While simple airs may be executed on instruments capable of the harmonics alone, and while such instruments are useful as accompaniments in musical bands, the cultivated ear soon craves a more copious and varied music. It is in seeking to satisfy this requirement that the diatonic scale has been adopted.

44. It is not our intention to enter into a description of musical scales, further than in brief terms to point out the general principles on which they are constructed. They who possess any metaphysical tendencies, will not fail to wonder at and admire that law of our mental and physical constitution by which a thing so mechanical as a mere movement

of matter is transmuted into an enjoyment at once so exhilarating and spiritual as music; by which the cares and fatigues of humanity are alleviated, and our thoughts are so promptly raised above their dull level.

45. It appears that Aristotle understood something of the nature of sound, and was aware that the distinction of notes in respect of pitch was due to the rapidity of vibration. Pythagoras thought the laws of music were identical with the laws of nature, and, if properly understood, were sufficient to explain nature's various phenomena. There seem grounds for doubt, however, whether the ancients were able to subject the vibrations to arithmetical calculation. However this may be, it is believed that the same natural or diatonic scale has existed in more or less completeness throughout all nations, barbaric and civilized. From this we must conclude that the elements of melody are simple, and founded on nature, and that they have been adopted by man from necessity, his ear leading him to choose that succession of notes which would yield agreeable cadence when they were sounded in succession, and which would comprise at the same time the greatest number of agreeable harmonics, and such is the character of the diatonic scale.

46. A few simple notes with well-marked intervals would doubtless first be held sufficient; and it is accordingly found that rude nations in general have rejected the more plaintive intervals of the minor scale, and have adopted what is strong and well marked. Such seems to have been the *old scale* of Scotch and Irish music, and which prevails yet in many of our national airs. The Chinese, Hindoos, and many of the tribes of the north of Europe, also have this character pervading a great deal of their music. As people, however, become more refined, the notes of the full chromatic scale become necessary to express the wider range of sentiment.

47. We shall now see how this scale may be explained. Let us take a string and stretch it between two points by a weight sufficient to make it give a clear sound when set in

vibration. When we halve the length of the string, we obtain a note the octave of the fundamental. Within this interval of a note and its octave are comprised the whole notes whether of the diatonic major or minor, or of the chromatic scale. Let us confine ourselves to the diatonic scale, and keep in view that the number of vibrations and the length of the string are always in inverse ratios—that is to say, half the string gives double the vibrations; a third, fourth, fifth, sixth, etc., gives three, four, five, six times the number of vibrations per second. Now, as the whole scale is to be comprised between one vibration of the note C and two vibrations of its octave, we must find what fractional parts of the string will be the simplest multiples of its entire length, for so we get vibrations which are in like proportions to the fundamental note of the string, and which consequently harmonise with it; and the simpler the proportions, the more entire will be the harmony. Commencing, then, by taking for our first note from C a part of the string $\frac{5}{6}$ of its whole length—for any proportion greater than this is not found to produce a note harmonising with the fundamental. Setting down then $\frac{5}{6}$ for the first division of the string, the simplest fractions we can find will run thus when arranged in the order of their magnitude, 1, $\frac{5}{6}$, $\frac{4}{5}$, $\frac{3}{4}$, $\frac{2}{3}$, $\frac{3}{5}$, and $\frac{1}{2}$: by marking these parts of the string we will find that we have divided it in such a way that by sounding any of the parts it will yield a note in perfect harmony with the fundamental note. Thus, therefore, we have a scale formed of the most simple possible concords. It is represented in music as follows:—

Name of note	C	E flat	E	F	G	A	C′
Vibrations	1	$\frac{6}{5}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	2
Intervals	1	$\frac{6}{5}$	$\frac{25}{24}$	$\frac{16}{15}$	$\frac{9}{8}$	$\frac{10}{9}$	$\frac{6}{5}$

The numerator of the fractions on the second line shows the number of vibrations each note performs, and the denominator the number of vibrations of the note C in the same time.

48. Such a scale is, however, liable to two objections. In the first place, the interval from E flat to E natural is not

sufficiently wide to be heard often with satisfaction; indeed these notes approach to a unison, and, like all imperfect unisons, sound ill together. The second objection to it is, that the interval between the E flat and the C is too great. The third objection is, that the interval between the A and the next note of the scale, namely, C′, is also too wide. This will be seen by inspecting the third line above given, where we have inserted the value of the intervals. To amend this scale of accords with the fundamental, so as to make it more useful, and arrange it so as to obtain the greatest number of the simplest concords with other notes, and at the same time to divide it more equally, we take D, a note which vibrates nine times for eight of the fundamental, and which also divides the interval between C and E well, and forms also a concord with its fourth, G, vibrating three times for four of that note. A note has only now to be found to subdivide the interval between A and C′, and accordingly B, which vibrates fifteen times for eight of the fundamental, suits the purpose.

Thus, then, we have the diatonic scale arranged :—

Name of note	C	D	E	F	G	A	B	C′
Vibrations	1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2
Intervals	1	$\frac{9}{8}$	$\frac{10}{9}$	$\frac{16}{15}$	$\frac{9}{8}$	$\frac{10}{9}$	$\frac{9}{8}$	$\frac{16}{15}$

In place of the fractional numbers, the intervals and the relative proportions of the vibrations may be represented in whole numbers, thus :—

C	D	E	F	G	A	B	C
24	27	30	32	36	40	45	48

49. This scale affords, as will be seen (Fig. 11), a variety of concords with the fundamental note, and also a number of perfect consonances with other notes, also a number of agreements approaching to perfect concord, while at the same time it possesses both sufficient regularity and variety. The inharmonious or imperfect intervals of this scale are, first, the interval between the F and B, which forms a flattened fifth, the interval being $\frac{45}{32}$; second, the interval between the C and B is an inharmonious seventh, being $\frac{15}{8}$, which are not

aliquot parts; and, third, the interval between D and C is a flat seventh, being $\frac{16}{9}$. It will be observed that none of the fractions marking the intervals of these imperfect notes will divide without a remainder, which is essential for perfect harmony. When the C, E, G are sounded together we have what is called the major triad. When G, B, D are sounded together we have the *dominant*, or second major triad, and when F, A, C are sounded we have the *sub-dominant*, or third major triad. The number of vibrations of the notes of these triads are all in the proportions 4, 5, and 6 respectively. The principal concords may be picked out by an inspection of the next figure.

50. Such is the diatonic major scale. The minor scale of C is a variation of it, and is formed by lowering the E a semitone in ascending the scale, and lowering the E, B, and A in descending. The effect of this is to give a somewhat irregular, sadder cast to the cadence, and it is adopted with best effect in bringing out the pathetic character of national music. The human voice, under the influence of plaintive or distressing emotions, naturally falls into such minor intervals.

51. Enough has now been said to show that the notes of the major scale are chosen so that their vibrations may bear as many simple proportions with one another and with the fundamental note as possible. We give below a sort of musical abacus of the major scale, by examining which a good deal of information regarding the scale will be obtained, and also further information connected with the physics of the subject, regarding which this explanation will suffice :—

(1.) The length of the divisions shows the *relative* length of the waves of vibration produced by each note.

(2.) The actual length of the wave is marked in feet and decimals at the left hand in each line.

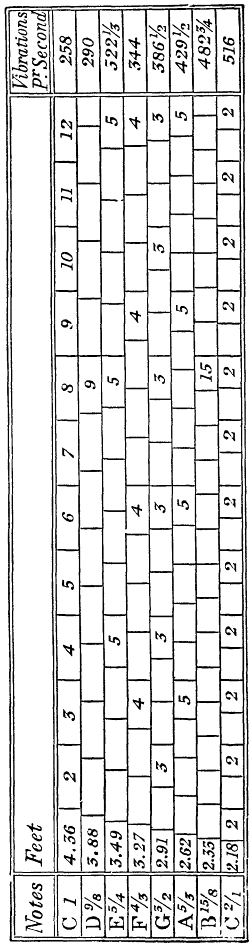
(3.) The name of the note and the proportional number of vibrations between it and the C note are given on the left hand.

(4.) In the column on the right hand is given the actual

number of double vibrations per second produced on sounding the note.

52. By inspecting this abacus with a view to find the notes which harmonise, we shall find it is those the termination of whose waves coincide once or more within the bounds of the table. Thus C and C′ show one wave of the former, coinciding with two of the latter. In the case of C and its third, E, four waves of the former coincide with five of the latter, and so on.

Fig. 11.

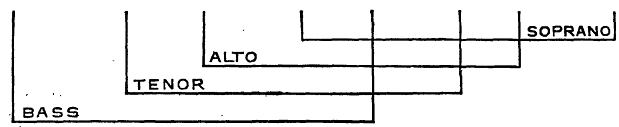


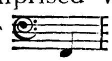
In pianos tuned for private rooms, the A note of the treble clef  will give about 420 double vibrations in the second. In the common six-octave piano, therefore, the lowest note, F, in the bass, will give 42, and the highest F of the treble, 2688 double vibrations in the second, the length of the waves of which will be, respectively, the one about 27 feet, and the other about 5 inches. It is in discriminating between the innumerable varieties and combinations of waves lying between these extremes, that the musical ear is exercised in listening to music—it is amidst distinctions so wonderfully minute as these that without any effort we revel in enjoying a performance of our common domestic instrument. The marvellous capabilities of the sense of hearing require no exordium beyond this statement—we see that even a comparatively simple exercise of its powers surpasses our comprehension. What shall we say of the

ability of this sense when we see it put to its stretch; as, for instance, in the case of the leader conducting a crowded orchestra, where the number and variety of vibrations are such as entirely to baffle arithmetic? And yet the practised ear of the leader detects a single note, or twentieth part of a vibration, out of time, and points his finger at the offender.

53. In singing, the compass of a good voice is twelve notes. Many voices will, however, extend to two octaves. The range of the human voice may therefore be represented. as under, for the four varieties of ordinary voice.

C D E F^1 G A B C^1 D E F^2 G A B C^2 D E F^3 G A B C^3 D E F^4 G A B C^4



Madame Catalani's compass is said to have been three and a half octaves. The ordinary compass of the human voice, from the lowest note of the bass to the highest note of the soprano, may be said to be comprised within three octaves, and four notes; namely, from F  on the bass clef to C  on the treble.

CHAPTER X.

SOUND (*Continued*).

SPEECH—ITS INTONATIONS—THE EAR—ITS STRUCTURE—RECENT DISCOVERIES.

54. IF music is a wonderful power, striking into the soul and controlling its emotional nature, how much more noble is speech, which addresses itself to the rational faculties. As it is the badge of our position in the scale, and marks us out as superior to all other creatures, so Nature had been inconsistent with herself had she not conferred on such an instrument powers befitting the importance of its office. But this has been duly attended to. Language has tones and modulations more various than music. It is not enunciated in unmoving symbols, as is the case in written language, but in notes, which become the most perfect exponents of the emotions of the individual who utters them. The majesty of man's voice, it is well known, exercises a control even over the fiercest animals, the firmness of a word has sometimes stayed a flying army, and the fate of nations has turned upon the tones of determination sounded by a single patriot. We all know how influential an ingredient in social and domestic intercourse is the melody of the male and female voice. We mention the two in order to point out that nature has here provided a contrast which yields the highest natural harmony. Nor would we omit the infantile treble which, like the ringing of tiny bells, fills up and gives richness to the graver music. Such is the power of speech as an instrument, irrespective of its principal function as the medium of thought.

55. The intonation of the voice in speech follows a dif-

ferent rule from that of music. In music each tone is a pure note of the scale, and the voice, or the instrument, passes by distinct steps from one note to another throughout the melody. There is a difference in the cadence of speech. Here also each syllable uttered *has its place on a scale*, and the intervals, whether they be ascending or descending, may be a tone, a third, a fifth, an octave, or we may pass to any note of the scale which the voice can reach. These notes, however, are not simple and pure as in music; on the contrary, in pronouncing the vowels and those consonants which admit of it, there is a slide of the voice upon each syllable. The voice strikes the radical note or pitch, and thence slides into a higher or lower note, at the same time decreasing in intensity till it, as it were, vanishes, and is succeeded by the following syllabic note. These notes are called ascending or descending concrete sounds. These syllabic slides may rise half a note, or even a lesser interval, or they may rise to the fifth or octave. The succession of sounds, in speech as in music, may be according to the diatonic scale, where the expression of firmness and determination is required, or according to the chromatic, when the tones are those of distress or supplication. The orator, like the accomplished performer on an instrument, knows how to sweep through all the scales; kindling with his subject, his voice will rise to its highest notes, and, if needful, will even break through its natural bonds into the falsetto, expressing thereby the utmost reach of utterable emotion; from this again he will, perhaps in the same sentence, subside into the low far-heard whisper, which, though no voice, yet finds its way both to the ear and to the heart.

Speech depends not on pitch, but chiefly on *quality*, and on the form of the sounds produced. The organ of speech is the most flexible of musical instruments. It can alter its arrangements so as not only to produce all the open or vowel sounds, but by changes in the form and condition of the throat, tongue, and lips, and by the position of these in relation to

the palate and teeth, it can infinitely vary these sounds. Speech, however, is mainly dependent on the forming of syllables; and this is accomplished by the great variety of ways in which we are enabled to open and shut off the vowel sounds. This is done by what we call consonants, which are strictly nothing more than the result of our employing the flexible parts of the organ, in the manner of valves of different forms, for opening, and then again quickly shutting off as we have said the various pure vocal sounds.

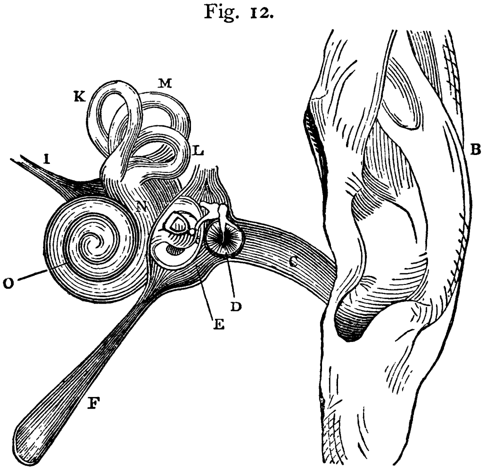
56. The organ which receives the rapid and complicated movements and combinations used in music and speech is the ear. The leading object in all the organs of sense is, that they be formed so as to bring the impression which affects them to bear with best effect on the nerve of sense with which they are supplied. In the description of the eye, we shall see the mathematical precision that is necessary in the action of that organ, in order that it may give the correct forms and positions of bodies. The office of the ear is entirely different from that of the eye, and in form and construction there is a corresponding diversity; they are both conversant with vibrations, but the eye must receive these vibrations radiating from the different points of objects, and must map them down on the retina with an absolute *precision of measurement.* The ear, on the contrary, receives the vibrations with which it is conversant, and leaves it to the mind to note their *duration and quality:* the former organ has thus to do with place, the latter with time; for an ear, therefore, a fine expansion of the auditory nerve is the only, or at least the prominent, requisite. Much more variety of structure is compatible with an instrument having this object, and we may say, much less nicety, than in the structure of the organ of vision. We find, accordingly, that in many tribes of the *articulata*, such as bees, grasshoppers, beetles, spiders, and in some of the *crustacea* also, such as the lobster and crab, the organ consists of a simple sac containing a fluid in which the auditory nerve is expanded, and the vibrations

are either communicated to the organ through the hard parts of the head, or through a membrane exposed to the air. In fishes, and in reptiles, the organ is also more simple than in man. In birds it is more complicated, though its form and arrangement differ somewhat from what is observed in the human organ.

57. In mammals the ear is a much more complex organ than it is in any of the lower classes of animals. So much is this the case, that it is a much more easy task to describe the human eye than the human ear. We shall, however, endeavour to explain the arrangements and uses of the principal parts of this organ as they exist in man, as these are understood.

The human ear may be described as consisting of the external, the middle, and the internal ear.

Fig. 12.



58. We need not say much of the conch, or external ear, B. It is partly fleshy and partly cartilaginous. It serves to collect the sonorous vibrations, and to direct them into the passage called the *meatus externus*, C, by which they are conducted into the head. We have only to touch, or rub gently, any part of the cartilage of this external appendage to find how well the sound thus excited is trans-

mitted to the inner ear. The passage which enters the head is nearly an inch in length, it is closed at the inner end by a membrane called *membrana tympani*, D, or the membranous drum of the ear.

59. Behind this .membrane, or drum, is the middle chamber of the ear, called the tympanum. It is a narrow irregular cavity formed in the hard substance of the temporal bone. It lies between the *membrana tympani* and the inner ear. From this chamber there is a passage called the eustachian tube, F, leading to the upper part of the pharynx, designed to open a communication for air between the tympanic cavity and the throat. (See Fig. 12, which is an enlarged representation of the human ear.)

60. The inner ear, or labyrinth, is the true sensory part of the organ of hearing. It is, like the middle ear, enclosed within the petrous or hard portion of the temporal bone. It may be described as consisting, externally, of three parts: the central part, or vestibule, N; the semicircular canals, L, M, K; and the cochlea, O. Out of the vestibule rise on the one side the three semicircular bony canals alluded to. Two of these, known as the superior and the posterior canals, unite in one pipe a little above where they enter the vestibule. These two have a nearly vertical position; the third, or external canal, is nearly horizontal and at right angles to the other two. These canals, as is shown in the figure, are dilated where they enter the vestibule into four jug-shaped expansions, or ampullæ, except the joint-entrance of the superior and posterior canals first mentioned, which is not dilated.

61. On the opposite end of the vestibule is the cochlea. This part, as its name implies, resembles a snail's shell, both externally and structurally. It is an elongated tapering tube, coiled two and a half times round a central hollow pillar, called the *modiolus*, or *columella cochleæ*, which it ascends in a spiral manner.

62. In the vestibule are two openings, namely, the *fenestra*

ovalis and the *fenestra rotunda*, the former opposite the centre of the *membrana tympani*, and the latter situated below the *ampulla* of the posterior semicircular canal. The openings into the vestibule are sealed by membranous coverings, to prevent the escape of the liquid with which it is filled. Such is the external form of that part of the inner ear which, in order to distinguish it from the *membranous labyrinth* situated within it, is called the *osseous labyrinth*. Within the osseous labyrinth which we have been describing, but separated from it by the fluid, perilymph, are membranous structures which, in the vestibule and in the canals, closely resemble in shape the osseous case in which they are enclosed. Besides being separated from the bony case of the labyrinth by *perilymph*, they are also filled with a similar fluid distinguished as *endolymph*. These membranous tubes and sacs may thus be regarded as suspended in the fluid contents of their bony case.

Throughout the whole of this membranous floating labyrinth are closely ramified the ultimate fibres and fibrils of the auditory nerve, and especially within the ampullæ and the sacs of the vestibule: in the fluid contents of which parts numerous loose, filamentous ends of the nerve are observed to float.

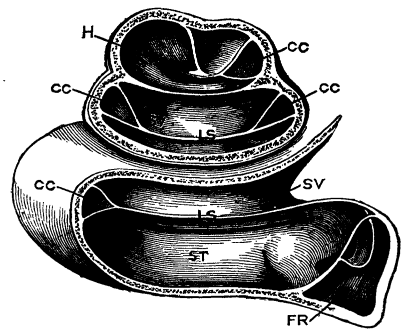
63. In contact with the nerves in the vestibule, and especially in the membranous ampullæ, and in the utriculus and sacculus within the vestibule, it is singular to discover a quantity of carbonate of lime, sometimes in little crystals (*otolyths*), at other times in a state of fine powder (*otoconia*). It is conceived that the object of these earthy particles is by their movements under vibration to act on the nerves, and give them a sharper impulse than is communicated by the fluid in immediate contact with them.

64. While the vertical and the horizontal canals are supposed, from their transverse relative positions, to be the means by which we distinguish the direction whence external sounds proceed, the singularly complex arrangement within the

cochlea, about to be described, leads us to conclude that it is in that part of the organ that the susceptibility to the finer modulations of pitch or tone exist.

The cochlea besides consisting of the scala, or winding bony tube, which we have mentioned, contains a farther interior arrangement which must be described. The winding bony *scala* is divided horizontally into two main passages, one above the other, formed in this wise (see Fig. 13). From

Fig. 13.



the side of the pillar, or modiolus, and extending about half-way across the passage in the fashion of an ascending spiral shelf, projects a spongy, thin lamina of bone, which follows the windings of the tubular scala, tapering off as it reaches the narrow and upper part. A membranous tissue connected with the bony lamina, and which is called the *membrana spiralis*, extends beyond the bony lamina, and serves as a continuation thereof; and thus, as we have said, the bony scalar passage is cut in two parallel ascending spires. The under one is called the scala tympani, the upper one, the scala vestibuli.

65. We are not yet done with the cochlea. A triangular portion of the upper passage just mentioned is partitioned off at its external side by a membrane known as Reisner's membrane, which thus forms a third though narrower ascending passage called the *canalis cochleæ*. Though the whole membrane which forms the floor of the upper passage is

abundantly supplied with nervous filaments, it is that part of it which forms the floor of the *canalis cochleæ*, and which is situated farthest from the modiolus, which is supposed to be the most highly organised portion of the hearing apparatus. This part, which has only of late years been investigated, has received from the name of its most successful explorer, the appellation of *the organ of Corti.* When the three upper layers of this membrane have been removed, it is found, when brought under a good microscope, to consist, as Dr. Bennet describes it ("First Book of Physiology"), of remarkable structures, resembling in appearance flat rods, placed side by side like the keys of a piano; these are the *inner rods of Corti.* Immediately outside these is a row of grooves, or depressions through which minute continuations of the nerves pass, to be connected with these rods. External to these is a second row of flat, transparent rods, and external to these, again, is another row, the *outer rods of Corti.* The inner rods are arranged so as to overlap the outer ones, and they are mutually inclined towards each other anticlinally, like the beams of a roof, so as during vibration to admit of the movement of the one on the other. It has been suggested by Helmholtz that these rods, by virtue of their varying lengths, vibrate to particular notes, and thus enable us to perceive these notes more clearly. To strengthen this view, there is found on the surface of the outer rods a row of three or four ganglionic nucleated cells, connected with them and with one another by delicate jointed processes.

66. The reader may think we have entered with unnecessary minuteness into the description of this highly complex organ. We have, however, done so designedly, because we believe it will be found an important axiom in physiology, that the more carefully we examine the structure of any of the organs of the higher animals the more evidence will we discover of minute and elaborate contrivance for rendering these organs as perfect as possible for the service which the higher mental principle requires of them. It would

seem as if nature, in her more finished productions, has ever at hand a store of accessory contrivances, which she can call into requisition for compassing her objects.

67. We have neglected to mention that the posterior wall of the tympanic chamber has at its upper part one larger and several smaller openings, L, which lead into irregular cavities in the mastoid process of the temporal bone, all of which cavities communicate freely with one another. The *meatus internus* is a short canal containing the auditory nerve (see Fig. 12).

68. As sonorous vibration affects all hard elastic bodies, we can easily conceive that the whole bones of the cranium, and especially that part of the temporal bone in which the cochlea and semicircular canals are imbedded, will be peculiarly subject to such tremors. The various cavities and hollow passages with which these parts of the inner ear are surrounded, by partially isolating them, will doubtless materially assist in rendering them susceptible to sonorous vibration.

69. The human ear as we have described it, is perfectly susceptible to sound. There is, however, another appliance for making it a more perfect organ. This consists in a chain of three small and curiously shaped bones. The *malleus*, whose long arm is attached to the middle of the tympanic membrane, is articulated into the head of the *incus*, whose long process again sustains the *stapes*, and this last and innermost link is attached to the *membrana ovalis*, on which it acts in the manner to be afterwards described.

70. The presence of these small bones is, as we have said, not essential to hearing; nor indeed is the drum membrane, for these parts have frequently been found detached without the hearing being destroyed; but the connection of this chain of bones adds greatly to the sensibility of the organ. Where these parts are wanting, the vibrations in the inner ear and in its nervous fibres must be affected solely through the agency of the aerial vibrations which enter the outer passage, and the chamber of the middle ear; when, however, the

membrana tympani and ossicula are present, there is a much more effectual transmission of sonorous vibration—for the membrana tympani is set into vibration, and this movement is directly transmitted by these small bones to the membrana ovalis, and to the fluid and nervous filaments enclosed in the bones of the inner ear.

71. Another important use of these little bones is that they regulate the tension of the two membranes of which they are the connecting link, and this is effected by the small muscles, the *tensor*, and *laxator tympani*, attached to the malleus, and by the stapedius muscle attached to the stapes. It is probable that the tension of the membranes can by these muscles be so adjusted as to enable us to hear with best effect, loud and feeble, high and low notes. By the action of these bones and muscles, the drum membrane, and the *membrana ovalis*, are generally pulled towards each other, and thus assume a convex form. The use of the *membrana rotunda* in this light is apparent; by its elasticity and its acting, in counteraction to the strain exerted by the *ossicula* on the membrana ovalis, it must necessarily give elasticity and spring to that strain, and prevent its acting in a jarring manner, which otherwise would be inevitable.

72. In concluding these chapters on sound, let us just make one reflection in connection with the subject. Suppose that man had not possessed the sense of hearing, and that the Author of his being had informed him of the existence of these subtle aerial movements of which we have been treating, and had freely offered him the fullest use of them in any way his imagination might suggest, how thoroughly would he, in all probability, have despised the offer. He would not have conceived the possibility of applying such trivial movements to any useful purpose, much less would he have anticipated that they might be employed as the media of intercourse between man and man, or between man and external nature; or that, when thrown upon a particular nerve, they would excite in the mind the most inspiring emotions of which

man's nature is susceptible. In his ignorance, we cannot doubt, he would have declined a privilege which, properly applied, is beyond all estimate valuable. Let all of us take a lesson from this supposed case. Man may not discover a new sense, but let him be assured that there is nothing existing in nature which may not be turned to many valuable and unheard-of uses. It is the privilege of genius to discover new uses for common things. Nearly every year is teaching us this truth. Nature's storehouse is spacious, and various are the rare materials which are placed at our disposal. The command given to man was to *subdue the earth*, and science is daily teaching us new ways of doing so, and showing us that not only the gold, and silver, and corn, and wine, and oil are valuable, but also that the thorns and the thistles may be turned to good account.

CHAPTER XI.

LIGHT.

NEWTON'S CORPUSCULAR THEORY OF LIGHT—UNDULATORY THEORY.

73. LIGHT is without doubt the most wonderful natural agent we are acquainted with; pervading, as it appears to do, infinite space; streaming from age to age from the remotest orbs the telescope can reach, and with a velocity which baffles our comprehension. And yet this wonderful agent, in a modified form, is placed under our personal control, so that we can at will create and at will extinguish it. As was to be expected, the investigation of its laws, and the attempts to discover its nature or cause, have exercised the curiosity of philosophers since physical science became a study. With this object it has been refracted and transmitted through every conceivable medium, its rays have been reflected in every possible way, and subjected to every variety of treatment that ingenuity could devise. All the phenomena observed have been laboriously collated and studied, with the view of finding a cause adequate to explain them, or with the desire of reconciling them to preconceived theory. The labour of two hundred years has accordingly borne its fruits; and especially during the present century, the phenomena connected with the polarization of light, and the interception of rays displayed in different luminous spectra, have established the undulatory theory of light on a foundation almost equivalent to a mathematical demonstration.

74. Newton, whose earlier labours and most brilliant discoveries were connected with the subject of optics, adopted a corpuscular theory; he imagined light to consist of exces-

sively minute particles of matter projected from luminous bodies with the immense velocity of nearly 200,000 miles in a second. He conceived that these particles possessed weight, *inertia*, and all the other properties of matter; and that by impinging on the retina, they produced in us the sensation of light. He accounted for their transmission through transparent bodies, and their reflection from polished surfaces, by supposing that the molecules of light, and of the bodies on which they strike, exert a mutual action of attraction and repulsion on each other; that the attractive influence causes the transmission of the particles of light through the transparent body, and the repulsive influence causes its reflection, and that it depends on certain circumstances whether the attractive or the repulsive principle will come into operation.

75. For instance, he supposed it possible that the molecules of light might possess two opposite poles, one of attraction and the other of repulsion; and that in proximity with the surface of every substance there existed certain strata, or *spheres of influence*, among which the attractive and repulsive action of the molecules of that substance alternately predominate; that these forces are inherent in the molecules of matter, and are exerted external to the surface, but in inconceivably close proximity to it. The molecules of light he conceived, during the whole of their progress through space, were continually passing through periodically recurring states, called by him *fits of easy reflection* and *easy transmission*, and this he imagined might be produced by the continual rotation of the molecules; this rotation causing them alternately to present their attractive and repulsive poles. It may be understood how, according to this supposition, on a molecule of light reaching the vicinity of the surface of any body, it would depend on a variety of circumstances whether it would be reflected or whether it would be transmitted; thus, for instance, on its *velocity* or *impetus;* on the *angle* at which it impinges upon or enters any of these supposed strata of influence; and upon the *varying positions of its poles at the time.*

76. If matters were favourable for its passing the strata of repulsion and entering within the strata of attraction, it would enter the substance of the transparent body; and as the forces of all the molecules of the penetrated body would in this case surround it, they would act on all sides of the molecule of light, and its course forward through the body, would consequently be in a straight line; but if, on the contrary, the molecule of light impinged on a stratum of repulsion when its pole of repulsion was presented; or if it impinged at an oblique angle with its pole of maximum repulsion only partially averted, the repulsive action of the stratum would predominate over the momentum of the molecule of light, and it would be reflected. In the event of the molecule being in a position to be acted on by the sphere of attraction of the body it impinged on, the effect of this attraction he conceived would be, if the molecule impinged obliquely, to refract or bend it downwards out of its original course, and in this way he accounted for the phenomena of refraction and reflection.

77. The *prismatic* colours of thin films Newton also attempted to explain. He had analyzed the sun's light by the prism, and discovered its constituent elements. He had observed also the prismatic colours which present themselves in the reflection of light from very thin transparent films, from cracks in crystal, and from soap bubbles. He found that there existed in these cases a regular succession of colours, always in the same order, and that the particular colour depended on the thickness of the film, or on the thickness of the interstice between the laminæ, or cracked surfaces. Thus in soap bubbles, if they be protected from the disturbance of the air, the colour is first white, but as they become thinner, the most beautiful colours start into existence, and arrange themselves in a certain order, in horizontal bands, about the top, as a centre, where the bubble is thinnest, by the descent of the soapy particles; and at the top of the bubble, when it reaches its extreme thinness, the colour becomes

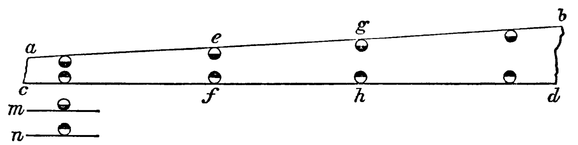
nearly black because the film from its thinness is there incapable of reflecting light.

78. Old and young take nearly equal pleasure in observing these emblems of what is at once most beautiful and most evanescent; few, however, have inquired the cause of the brilliant and changing hues thus presented. The reflective mind of Newton allowed none of Nature's presentations to pass without the homage of profound meditation. As soap bubbles were too ephemeral to be made the subjects of scientific measurement, he discovered a suitable substitute—he took a convex lens of ten or twelve feet focus; this he laid on a plane glass so finely polished that the two might touch at only one point. These glasses were exposed freely to the light, and on looking through the lens from above, he found the point of contact to be represented by a black spot, and surrounding this appeared a succession of as many as six or seven rings of varied colours. The first ring possessed the following order of colours: in the centre black, then very faint blue, next brilliant white, followed by yellow, orange, and red. The second ring, inner part dark purple or violet, then blue, green, vivid yellow, and crimson red; and each succeeding ring had a somewhat modified succession of the same colours, the rings growing more and more narrow, and the colours more and more faint and indistinct, as they receded from the centre.

79. Knowing the curvature of the lens, Newton was enabled to calculate the distance between the two surfaces of the glass plates where the different colours presented themselves, and he ascertained that at the brightest point of the first ring the interstice between the plates was a 178,000th part of an inch; and whatever might be the curvature of the lens employed, he found that this colour always appeared at the point where the space between the glasses was of the same thickness; and so in like manner, with regard to each colour throughout the different rings, he found that there existed a constant relation between the tint seen and the thickness of

the interstice between the two glasses. It was to explain these phenomena that Newton devised his doctrine of the *fits of easy reflection and transmission,* which he also applied, to account for the reflection and transmission of light from natural objects. He justly conceived that the thin lamina, or interstice, of air between his two glasses, separated the compound solar light into its elements, and so produced the coloured rings ; and he explained it in this way. He conceived that each of the seven elementary colours had a fit of easy reflection and easy transmission, of a definite length peculiar to itself, and which differed in each colour ; the violet having the shortest, and the red the longest, and each intermediate colour possessing an intermediate length of fit, in the order of their succession in the spectrum.

Fig. 14.



80. Let us now see how this would act. Suppose *a b* and *c d* to represent the upper and under surfaces of a very thin film of air, glass, or any other transparent body, immensely magnified, and which film thickens towards the right hand. From the explanation already given, it will be understood, according to Newton's theory, that molecules of light, composed of all the colours, falling on the upper surface, *a b,* in equal proportions of each colour, an equal number of each colour would, according to the law of chances, impinge on that surface in phases, to cause them to be reflected ; and a certain number also of each colour would impinge in opposite phases, permitting them to penetrate that surface, and to reach the under surface *c d.* How many, however, of those which have reached the under surface would be reflected from it, and how many would be transmitted through it, would depend on the phases of their fits of reflection and transmission when they

reach that surface. Let us suppose, in the first instance, that the film is of extreme thinness; the molecules which enter the upper surface of such a film will have no time to alter their fit before they reach the lower surface; they will, therefore, pass right through the film, which will at that place appear nearly black, there being no reflection of light from the lower surface.

81. Let us, however, suppose, as a second case, that a number of the molecules of solar light enter the upper surface of the film at the point *a*, where it is somewhat thicker; it is evident that all such must enter in some phasis of their fit of easy transmission, or they would not enter at all. Let the molecule at *a* represent one of the molecules of the *violet ray*, which has the shortest fits, and which has just entered the upper surface, presenting its pole of transmission, which we have in this figure made black, to distinguish it from the pole of easy reflection, which we have left white. It must be kept in view that this molecule, and all other molecules of light, must be conceived to be performing a constant and rapid revolution transverse to their axes as they dart forward. When this violet molecule reaches the lower surface at *c*, we shall suppose it to have got through half a fit; it will therefore reach *c* in a phasis opposite from that at which it entered the upper surface; its pole of reflection will therefore be presented, and it and all other molecules of violet light entering in like condition will be reflected upward through the film into the eye, and the colour of violet will present itself to the eye looking down on this part of the film. It is evident that none of the other colours will be prepared for reflection at this point, their fits being longer than those of the violet. The molecules of yellow light, however, will be in a position to be reflected at *f*, where the film is thicker, and the molecules of red light at *h*. Supposing the film at *a* to have been double the thickness, the molecule of violet light would on reaching *m* be in precisely the same phasis of its fit as that at which it entered the upper surface at *a*, and it would therefore not be

reflected but *transmitted through the film.* Suppose, again, the film to have been three times the thickness, the molecule on reaching *n* would again be in its fit of *reflection.* This it will also be at *d*, where the film has this thickness: and at this point of the film it will suffer a second reflection; and beyond this the yellow and red will also be again reflected. Thus, at all thicknesses of the film which are multiples of the fits (as from *a* to *m*), the molecules of the particular colour will be *transmitted* at the under surface; and at all thicknesses of the film which are odd multiples of the length of the half fits, as 1, 3, 5, 7, 9 (as from *a* to *n*), etc., these molecules will be reflected at the under surface. In this way Newton accounted for the successive rings of colour observed when he laid a curved glass surface upon a plane glass. It also accounted for the colours observed in soap bubbles, the varying colours depending on the varying thickness of the bubble.

82. From the consideration of the colours of thin films, he passed to the consideration of the colours of natural bodies, and extended his theory to the explaining of them.

(1.) He assumed that matter consists of solid molecules or atoms, and that all matter is porous, *the pores or intervals occupying*, according to him, *a much larger space than the solid particles.*

(2.) He conceived that the solid particles or atoms which constitute different substances, have a size peculiar to the particular substance, and that these atoms are transparent, or nearly so.

(3.) He conceived that the opacity of opaque bodies arose from the number of reflections the molecules of light underwent among the atoms of such bodies, by which they became as it were lost within the substance.

(4.) The colours of bodies, he considered, arose from the same cause which produced the colours in thin films, namely, from the size of the atoms of the particular substance, and the thickness between the anterior and posterior surfaces.

83. It is now known that Newton's explanation of colours

is applicable only to what are called false colours, such as those variable tints observed in mother-of-pearl, feathers, insects' wings, and in striated surfaces, where the laws of the interference of light, as explicable on the undulatory theory, produce the iridescent play of colour observed. With regard to true colours, such as are observed in powders, in dyes, in flowers, and such like, another explanation must be sought.

84. Such is a brief statement of Newton's theory of light. Our thus presenting it requires no apology, for though the corpuscular theory is now superseded, Newton's experiments and speculations will not only be ever regarded with peculiar reverence, but they will be studied as forming a most instructive chapter in the history of physical discovery; for it must be admitted that the speculations, no less than the discoveries of Newton, have been the basis on which much of the undulatory theory has been built, though the phenomena are explained on a different principle.

85. Regarding true colour, we may state that the cause of the variety of colour in nature is a very interesting subject of enquiry. Certain ruling principles of great simplicity and beauty have been accepted, but some time will yet elapse before the subject is thoroughly exhausted.

86. It has long been known that the colour of bodies depends on the rays they reject or radiate, and not on those which they absorb. It is only recently, however, that the physical law which regulates this absorption of rays has been suggested.

87. It is now pretty generally believed that when luminous rays are absorbed by an opaque body, this arises from the ethereal vibrations having the power of impressing on the substance which they enter vibrations which synchronise with their own vibrations.

88. Experiments connected with the production of the anomalous bands observed in luminous spectra, have proved that certain of the luminous rays of incandescent bodies have a tendency to be absorbed when passing through vapour of

the same substance. This discovery has been successfully applied in explanation of the absorption of light and heat in liquids and in solids, as well as in aeriform media.

89. It is doubtless a very beautiful physical law, that the passage of luminous vibrations, whatever may be their pitch, are partially arrested or absorbed when the molecules of the substance they penetrate vibrate in accord with them.

90. When light thus enters an opaque black substance, we are led to infer that its vibrations, being all in harmony with the vibration of that substance, expend themselves in producing molecular motion, and are thus probably converted into heat, and that the substance appears black from the circumstance of none of the luminous rays being radiated.

When light again enters another opaque body, the vibrations of some of the rays may synchronise and be absorbed: others, whose periods of vibration do not harmonise with those of the molecules of the substance, either from some peculiarity in the molecular structure of the body, or perhaps from the vibratory disturbance produced in it by the absorbed rays, do not pass through, but are radiated out after passing through, some of the superficial strata of molecules. The colour of the substance in this case will evidently depend on the rays which are thus radiated, while, as we have said, bodies whose atoms vibrate in unison with the luminous rays, absorb and utilise all such rays, and appear black.

91. Transparency, on the other hand, is supposed to arise, as one of its causes, from the circumstance of the vibrations of the ethereal and atomic bodies not harmonising. The luminous vibrations in such a case pass through such bodies, provided the molecular structure of such bodies allows it. The molecular structure is evidently of primary importance in all such questions. For we see that while the diamond is transparent, a piece of charcoal is one of the most opaque of substances, though chemically the atoms of the two objects are the same.

We can thus see how some bodies, such as water and glass,

transmit luminous rays, but arrest the extra red, or heating rays; and how rock-salt freely transmits radiant heat rays, but radiates them very feebly. But, as we have said, much has still to be explained connected with this difficult subject, and there are peculiarities in the constitution of many bodies which makes them appear to contradict the general law: its operation, however, we cannot doubt, is very extensive and important.

92. The undulatory theory of light was propounded first by Huygens, and was supported by Descartes, Hooke, Euler, Young, Fresnel, and other illustrious men. It has gradually gained the ascendant. By it all the observed phenomena may be much better explained than by the corpuscular theory. The inconceivable velocity of light, for instance, is almost incompatible with the supposition of a darting of corpuscles: and it is almost impossible to conceive a power sufficient to produce a projection of such minute bodies with a velocity so great.

93. The main points assumed in the undulatory theory are these:—

First, that an elastic ether pervades all space, and penetrates all material bodies, occupying the intervals between their atoms, and vibrating freely, particularly in such substances as are transparent.

Second, that this ether is capable of being set into vibration by the action of various causes, such as by combustion, electricity, mechanical force, and other means. That the undulation thus excited in the ether is propagated on principles somewhat analogous to waves of sound, but with a velocity infinitely greater, namely, at about the rate of 186,000 miles a second.

The nature of ethereal vibration would seem, in many respects to differ from that of atmospheric vibration. The phenomena of polarized light leads us to conclude that the vibrations of light are not, as in sonorous vibration, by a back and forward motion of the medium, in the direction of transmission, but in a direction transverse to the direction of the ray, like

the vibrations of stretched cords. A beam of natural or unpolarized light would seem thus to consist of millions of infinitely small rays, vibrating either at right angles or in every variety of plane, and so mixed that every conceivable plane of vibration is represented in a beam of light. When polarized, however, these rays are caused to vibrate more or less in parallel planes.

Third, that the impact, upon the retina, of the molecules of this ether thus set in motion, excites in us the impression of light.

Fourth, that as in sound the frequency of the sonorous waves determines the pitch or note, so, on this theory of light, the frequency of the pulses in a given time determines the impression of colour. In all solar light, therefore, it is conceived there exist undulations of different lengths corresponding to each colour. By following the experiments made by Newton, and which we have explained, it has been found that the lengths of these luminous undulations in air, or the value of the wave for the different rays, as also the number of times they are repeated in one second, are as in the following table :—

WAVES OF UNDULATION.[1]

Colours.	Length of an undulation in parts of an inch in air.	Number of such undulations in an inch.	Number of undulations per second.
Extreme Red	0·0000266	37,640	458,000,000,000,000
Red	0·0000256	39,180	477,000,000,000,000
Intermediate	0·0000246	40,720	495,000,000,000,000
Orange	0·0000240	41,610	506,000,000,000,000
Intermediate	0·0000235	42,510	517,000,000,000,000
Yellow	0·0000227	44,000	535,000,000,000,000
Intermediate	0·0000219	45,600	555,000,000,000,000
Green	0·0000211	47,460	577,000,000,000,000
Intermediate	0·0000203	49,320	600,000,000,000,000
Blue	0·0000196	51,110	622,000,000,000,000
Intermediate	0·0000189	52,910	644,000,000,000,000
Indigo	0·0000185	54,070	658,000,000,000,000
Intermediate	0·0000181	55,240	672,000,000,000,000
Violet	0·0000174	57,490	699,000,000,000,000
Extreme	0·0000167	59.750	727,000,000,000,000
			Taking the velocity of light at 192,000 miles per second.

[1] See Encyc. Metrop., Art. Light, Part III.

94. The undulations of light which are visible to the human eye, have, in their relative variety of length, and rapidity of succession, a much smaller range than those of sound. For while the ear discriminates a range of notes (see p. 107) extending to nine octaves, the eye embraces less than an octave; in fact, what is about equal to a minor sixth. It must be kept in mind, however, that we have evidence of the existence both of slower and of much more rapid vibrations than those recorded in these tables, and which are invisible to the eye.

CHAPTER XII.

LIGHT (*Continued*).

RADIATION OF LIGHT—DECREASE OF INTENSITY—APPARENT BRIGHTNESS—SUPPOSITIONAL MODES OF VISION.

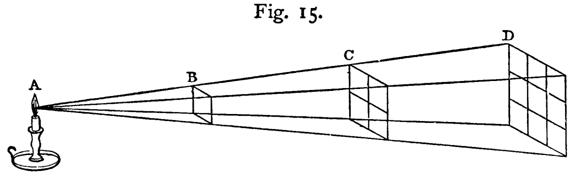
95. LIGHT, whether it be an emanation of particles, or whether it be the effect of vibration, obeys certain invariable laws. The first we shall mention is this: a luminous body radiates light equally in all directions. The rays from the sun obey, in this respect, the same law as those from a candle, from a house, a tree, or any other luminous or illuminated body. It is owing to this that objects are equally visible in all directions. The rays streaming from a candle, and which have their source comprised within little more than an inch, diffuse themselves equally throughout space; and though they may not be sufficient at a distance of ten or twelve feet to enable us to distinguish the letters of a book, yet that their power is merely diminished by distance, and consequent dispersion, but not extinguished, we may easily satisfy ourselves. By retiring to the distance, say, of a mile from the candle, if the air be clear and the night dark, the bright twinkle of this humble source of light will still be visible: and by retiring three or four times that distance, the lost light may by means of a telescope be again recovered.

96. This space-piercing property enables the sun to dispense in just proportion that wonderful influence, for the reception of which the various planets are made to circle round his throne. The same law enables the star and the beacon-light to guide the mariner during the darkest night. The traveller by land also receives the benefit: crossing the moor he catches the twinkle, which tells him of life

and indoor comfort. "How far yon little candle throws his beams," said Portia, as she neared her old mansion, richly freighted with the treasure of a good and successful achievement, when all nature spoke poetry to her; "so shines a good deed in this naughty world." Good and evil obey this same law of radiation; few tapers, and few good deeds, however, have shone so clear and so far as those of Portia: lighted by the poet's fire, the rays are doubly bright.

97. Were it not for this equal radiation of light on all sides, objects would of course be visible only when we crossed the line of emanation, and when we moved out of that line they would instantly be lost to the eye. This law of equal radiation draws after it another consequence, we mean the rule of decreasing intensity of light, dependent on the distance of the luminous body. This rule, though expressed by philosophers in succinct and rather intricate phraseology, may be easily divested of difficulty and exhibited to the eye; and as the same rule is of very extensive application, holding true with regard to light, heat, sound, gravity, and, in fact, nearly all powers or influences acting from a centre, we shall first state the rule, and then exhibit it. *Gravity, light, heat, etc., decrease inversely as the squares of the distance.* It is this rule which keeps the earth in its place as it wheels round the sun, and which regulates the amount of heat and light which that luminary dispenses to it. The law and its proof may

Fig. 15.



be exhibited to the eye thus: Let B be a board one foot square placed one yard from the candle A, and which receives the pyramid of rays emanating from the light. When this board is removed and a second board of the proper size is placed at C, a distance of two yards from the candle, it is evident to the eye that this second board will intercept

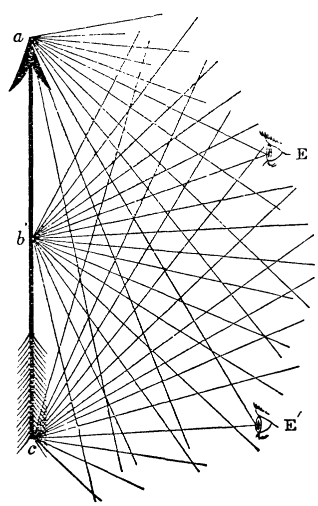
exactly the same number of rays as the first board, and it is equally evident that its sides will be double the length, and its area therefore four times as great as the first board. The intensity of light it receives is consequently a fourth of what illuminated the first board. A third board placed at D, three yards distant from the candle, will require to have exactly nine times the area of the first board to enable it to intercept the same pyramid of rays, and will therefore only receive a ninth part of the intensity of illumination, the same number of rays being diffused over nine times the surface; and so, by supposing it removed four, five, six, seven times the distance of the first board, its brightness will be inversely as these numbers squared, namely, a 16th, a 25th, a 36th, etc.

98. In explaining this law we have taken the instance of a body generating light; the law holds the same, however, with illuminated bodies. It must be kept in mind that we have been talking of the *amount of rays* which illuminate bodies at different distances. The *apparent brightness* of luminous and illuminated bodies at different distances is an entirely different matter; and it requires some reflection to understand how the apparent brightness of objects should at all distances appear the same, except in so far as the rays are impeded by an impure atmosphere; and yet this is the case. Every one must have observed that a distant corn-field on a clear day is just as bright as a near one, and a candle at a distance seems just as bright as when held in the hand. To understand the reason of the apparent brightness of objects continuing the same at different distances, notwithstanding that the real amount of light thrown by them into the eye decreases in the rapid ratio above stated, we must keep in mind the important circumstance that the *apparent size* of objects decreases exactly in the same ratio as their illuminating power. Thus a white target at a distance of 300 yards, throws only a ninth part of the light into the eye that it does at 100 yards; but its image on the retina, *i.e.* its apparent size, is also only one-ninth: it is evident,

therefore, that the intensity of impulse falling on each definite point of the retina, and on each microscopic nerve fibril, must remain unaltered, whatever may be the distance of the object. In other words, an equality between the apparent size and apparent brightness is maintained.

99. Knowing then the law of radiation of light, we have to consider a little more carefully the course which rays issuing from an illuminated body will take, and the important optical results which follow. The colourless light of the sun falling on any object, take for example a house, undergoes a change by its connection with the object: part of the elements of the ray are absorbed or stifled in the substance of the object, others will be radiated from it on all sides. Each part of the house's surface throws off a particular ray, according to the nature of the material; thus the general aspect of the roof, walls, door, windows, and rails, will be red, blue, white, green, or any other colour, according to circumstances. As we approach nearer, however, we discover that each minute point has its own peculiar tint, and is in point of fact radiating light and colour as from a centre. To understand how complex this phenomenon is, and how irreconcilable it is at first sight with the possibility of distinct vision, we exhibit an arrow as an object illuminated by the light of day. Not to make confusion more confounded, we shall select only three points of the arrow, *a b* and *c*, and represent the actual course of the rays issuing from them, and we place the eye of the observer at E and E′. Now, given an eye placed in such circumstances with rays entering it at all angles and from all

Fig. 16.

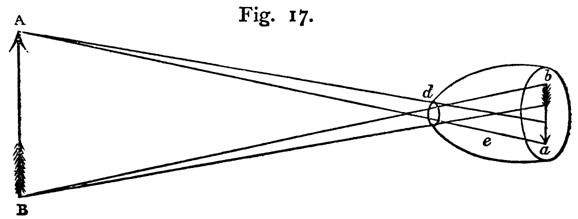


points, let the reader say how such a thing as vision is possible. It would seem that confusion and not vision must be the unavoidable result; and such would be the case were it not for the peculiar structure and office of the eye.

100. It is evident that the rays from this arrow falling upon a plane surface, say the wall of a darkened room, would not produce on it any image of the object. In the same way, were the eye a plane surface supplied with nerves sensible to light, and able to discriminate the qualities of shade and colour, it would still not be in circumstances enabling it to exercise any discrimination regarding the colour or form of the object; for every portion of such an eye being illuminated by rays from every portion of the object, a total mixture and confusion of rays would be the result. This we shall call *case the first*, in which there is *no vision*, but merely a measure of *illumination* caused by the object.

101. Let us take another case, in which the same nervous surface we have just supposed is placed in a more favourable position, and see if we can make any approximation to vision with such an organ. Let us suppose such an eye, or flat surface, suffused with an expansion of nerves sensible to light,

Fig. 17.

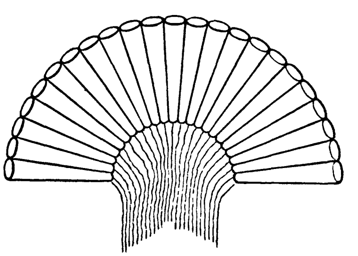


to be placed in a dark cavity of the head *e*, and light to be admitted to it through a small circular aperture *d*; a modification of vision might in this way be obtained, as represented in the figure. Certain rays, from every part of the object, it will be observed, enter the cavity at the circular opening; those from the upper part illuminate a small space at the lower part of the cavity, and those from the lower end of the object illuminate a space at the upper part; and thus a sort

of image of the object is thrown on the bottom of the cavity: at least we have managed by this contrivance that different parts of the dark surface are illuminated by different parts of the object, and this is one step towards vision. It is evident, however, that owing to the divergence of the rays as they enter the pupil of such an eye, each *point* of the object is not represented by a corresponding *point* on the retina, but each *point* of the object has its corresponding *space* on that expansion. Now the criterion of perfect vision is, that the rays from *every point of the object* shall be concentrated on a *corresponding point of the retina.* As the rays, however, from neighbouring parts of the object, will in the arrangement supposed overlap each other, *indistinct vision* must necessarily ensue. Such as it is, however, a dull representation of the object would be thrown on the retina of such an eye. Another defect in such an eye is this: as the aperture or pupil requires to be very small, very few rays would enter, and the image would consequently be very faint as well as very confused. Such an image of external nature we may obtain any day, by forming a small round hole in the window-shutter of a darkened room: the forms of external objects, the colours of the clouds and sky, and the waving of the trees, will appear evidently enough portrayed, in an inverted position, on the wall opposite the aperture, or on a piece of paper held up to receive them.

102. Having now acquired some idea of what is essential for vision, if the ingenuity of the reader were taxed, he might perhaps—though this is doubtful — suggest another contrivance by which a species of vision, or at least a mode of obtaining a knowledge of the shapes and positions of external objects, might be obtained. Let us suppose, for example, that instead of the

Fig. 18.



cavity which we have imagined, we possessed a round prominence placed on a convenient part of the body, and that this were thickly set with innumerable closely packed hollow tubes, all resting on a spherical nervous surface, and each tube pointing outwards from the centre like radii, as represented in the figure, and that each tube possessed a nervous fibre, it is evident that the light coming from different objects placed around, or from different parts of any near object, would enter only the particular tubes pointing in that direction ; while the light from all other objects, to the right or left, would be effectually excluded. By an instrument of this kind, it is clear there might be afforded a certain measure of knowledge of the forms and positions of external objects. *And such, in fact, though with some important adjuncts and improvements, is the nature of the eyes of insects, and of the crustacea, or crab family.*

CHAPTER XIII.

LIGHT (*Continued*).

REFRACTION OF LIGHT IN PARALLEL AND IN TRIANGULAR-SIDED PRISMS—THE SOLAR SPECTRUM: MODERN DISCOVERIES—RATIO OF THE SINES—LENSES—HELMHOLTZ ON DEFECTS OF THE EYE.

103. HAVING acquired some knowledge of what is needed in an organ of vision, namely, the power of causing the rays from every point of an external object to fall upon a corresponding point of the retina, in order that we may learn how this is effected by the human eye, it will be necessary to consider some other properties of light, and, in the first place, the laws of *refraction*.

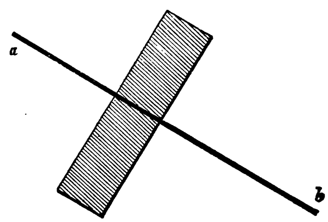
104. We have already considered the subject of the *radiation of light*, and shown the necessity for it in order that vision may be possible; we have also seen how this law, though absolutely necessary, nevertheless throws a mechanical difficulty in the way of vision, and requires a mechanical contrivance to overcome it. The difficulty can only be fully removed by means of optical instruments, capable of counteracting the radiating tendency of light by acting on its *refrangibility*.

105. Whatever may be the nature of light, we observe that so long as it passes through a vacuum, or through any transparent medium of uniform density, its course is continued in a straight line; immediately, however, that a ray passes from one medium and enters obliquely a medium of a greater or less density, it suffers a flexion or bend; and should the same ray pass successively through ten or twenty different media, falling on them not at right angles but obliquely, it would suffer just as many bends or refractions as it entered

and as it quitted each medium, provided each possessed different density or power of refraction.

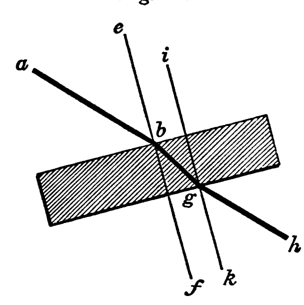
106. As the rays from the sun come to us from so great a distance, they may be considered not as diverging, but as being, as nearly as possible, parallel. We shall therefore explain the refraction of a parallel ray by admitting a pencil of light direct from the sun through a hole in a well-closed window-shutter, as represented below. The pencil passes through the air in a straight line *a b*, and it would continue in this line; we present, however, a plate of thick glass, whose sides are parallel, and in the first instance let its surface be presented at right angles to the direction of the ray. The interposition of the glass in this way produces no effect on the direction of the ray: it passes through the plate in the same line that it entered it, and will fall upon the same spot of the opposite wall or floor as it did before the glass was presented.

Fig. 19.



107. Let us alter now the position of the glass, presenting it at an oblique angle, as shown in the figure. The ray, or the particles of the vibrating medium, *immediately before entering* the substance of the glass, is acted on by its attraction, and is drawn downwards in the direction tending *towards* the imaginary line *b f*, perpendicular to the surface of the glass. In this direction it would proceed through the substance of the glass, however thick it might be; but when it comes to the lower surface, and enters the air, a rarer medium, it immediately is acted on by the same attraction of the substance of the glass, and suffers a second refraction;

Fig. 20.

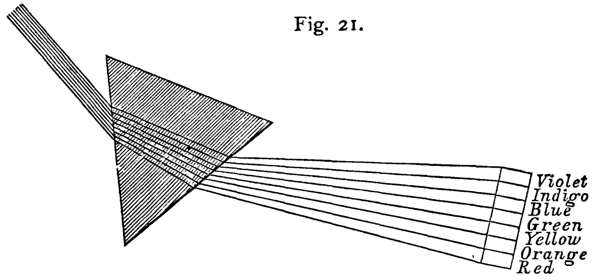


but in this instance, passing from a denser to a rarer medium, it is bent in an opposite direction *g h*, namely, in a direction *from* the perpendicular *g k* towards the surface of the glass, on the side next which it emerges: and, as might have been expected, the angle of refraction *from* the perpendicular, as it quits the denser medium, is exactly equal to the angle of refraction *towards* it as it entered the glass. The ray will therefore proceed from the glass in a line *g h* parallel to the original direction *a b*. It will, however, fall upon the floor or wall at a somewhat lower level, as is shown in the figure. The angles *a b e* and *b g i* are the angles of incidence at the upper and lower surfaces, the angles *g b f* and *k g h* are the angles of refraction.

108. Let us next subject this pencil of light to the influence of a three-sided prism of glass whose sides are not parallel, held with one of its angles downwards, and let the ray fall obliquely on one of its sides, as represented in Fig. 21. The phenomenon that presents itself cannot fail to excite both surprise and admiration. The ray of light, pure and colourless as it entered, becomes expanded in an oblong form, or, as it is expressed, the ray suffers a certain amount of dispersion, and exhibits the magic hues of the rainbow, and the colours are arranged in the same order of succession. These expanded rays will now be found to fall on a higher point of the floor—the original ray has therefore been refracted or bent from its original direction through the agency of the glass; and it will be observed that the red ray has suffered the least refraction, and is lowest on the wall or floor: this colour is more brilliant than any red that can be produced by any known dye. The red passes gradually into the orange, and this again is succeeded further up by a pure yellow; after which comes a vivid green; after which a blue, which deepens into the purest indigo; and the extreme bounds of the indigo is succeeded by a feeble violet; the violet occupies thus the upper part of the prismatic spectrum, and is most refracted; and the red occupies the lower part, and is least

refracted. An inquiring mind might question the cause of this wondrous transformation of the pure light of heaven, as Newton did, and, were he equally bent on a solution, might perhaps arrive at the same conclusion as he, viz. that colourless light is not simple, but a compound or union of rays of different elementary colours.

Fig. 21.



Such was the analysis of solar light obtained by Sir Isaac Newton by means of the prism. His was the first rational and successful attempt to explain light as consisting of the syntheses of different coloured elementary rays. His theory was marked by the intuitional sagacity which distinguished all the judgments of this great seer of nature. Nor does it detract from his merit that we have since ascertained his analysis to have been neither complete nor entirely free from error.

It has since Newton's time been discovered that other rays, besides those which are visible, exist in the solar spectrum. Thus the most powerful heating rays are found to extend beyond the reach of the visible red rays; and the most powerful chemical rays lie beyond the violet end of the spectrum.

Other discoveries of very great interest have also been made; thus in 1802, by admitting a beam of sunlight through a narrow slit, Dr. Wollaston obtained a much more perfect spectrum than that formed by Newton, when operating on a round beam. In this improved spectrum Wollaston observed that the sun-coloured bands were not continuous,

but were crossed by some dark lines transverse to the spectrum.

109. Professor Fraunhoffer, of Munich, on examining this spectrum by means of a telescope of low power, discovered the existence of a much greater number of these dark lines.

110. In 1814 he formed a diagram, in which the relative distances of 576 of these lines were carefully mapped down. This diagram has ever since been employed as the standard, by reference to which all other spectra have been described. In Fraunhoffer's diagram the eight principal dark lines are designated in their order, by the letters A B C D E F G and H. The line A being in the red, and the line H in the violet colour.

111. MM. Bunsen and Kirchhoff made the next onward step. By employing a succession of prisms, and thereby greatly lengthening out the spectrum, they discovered 2000 dark lines. The relative distances of these they marked very carefully by means of a telescope traversing a graduated circle.

112. It was next ascertained that different solid and fluid bodies, when incandescent, produced each their own peculiar spectrum ; and that while the light of such substances have continuous spectra, the spectra of gases, and of glowing vaporised substances, have each their peculiar bright-coloured lines, which cross the coloured bands. It was by-and-by further discovered by Kirchhoff that these latter bright lines corresponded in their position with certain of the dark lines of the solar spectrum. This circumstance was pregnant with meaning, and Kirchhoff accordingly availed himself of it, as affording a means of explaining the existence of the dark lines observed in solar light. He announced that the light from solid and fluid bodies, and which naturally yield continuous spectra, have certain of the rays absorbed in passing through gases, or through such incandescent vapours as yield corresponding or sympathetic luminous vibrations. In other words, that incandescent vapours absorb rays of the same

refrangibility as those they emit. Thus was established another agreement between the laws of light and sound, and thus another proof was afforded of the reality of the undulatory theory of light. For, as it is known that in sound notes of a particular pitch cause the vibration of such stretched cords as are capable of vibrating in unison with them, and expend themselves in producing such vibration, so the experiments of Kirchhoff went to prove that the same law operated in the case of luminous vibration. For if the rays of a luminous substance are absorbed in passing through the volatilised vapour of the same substance, a little reflection may lead us, as it led Kirchhoff, to see that the explanation of it is this: that the atoms of the *vapour* and of the *solid* being in their nature identical, may be expected to vibrate in a similar manner; and that the luminous vibrations which the atoms of the solid excite, will therefore produce corresponding vibrations in the atoms of the vapour with which the glowing solid is surrounded, and will be absorbed and utilised in producing them.

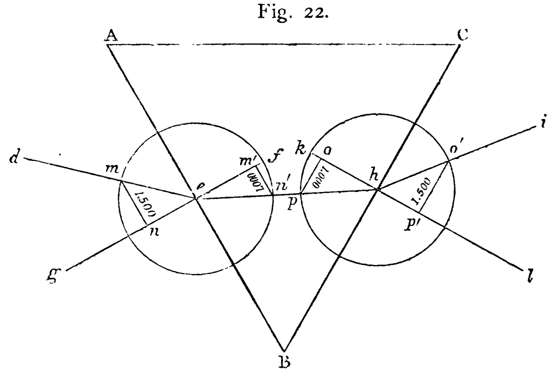
By experimenting with a great variety of different substances, those who have devoted themselves to these highly interesting investigations, have been enabled to analyze the light of the sun, of comets, of different planets, fixed stars, and nebulæ; and by the different spectra these bodies yield, they have been enabled to tell us, not only the solid ingredients of which they are composed, but also the nature of their respective atmospheres. They have already discovered several new chemical elements on our earth; and regarding the nature of various nebulæ, they have settled the question so long disputed, and proved some of these nebulæ to be clusters of stars, and others to be vapour not yet consolidated. They have also explained the cause of the sudden brightness of certain varying stars, and found that it arises from outbursts of hydrogen gas; and in the case of certain other stars, they have been enabled, by the spectra which they yield, to determine the rate at which they are approaching us, or are receding from us in space.

113. The light of the sun is thus ascertained to arise from the white light of the incandescent nucleus of that great orb; and the dark lines in the solar spectrum establish that this light passes through an atmosphere which surrounds the luminous body, and which consists of the volatilised vapour formed by the incandescence of the innumerable ingredients of which its orb is composed.

The study of the solar spectrum would also lead us to the conclusion that solar light is neither a compound of the seven visible colours of the spectrum, as Sir Isaac Newton surmised, nor yet of the three primary colours, whose mixture, Sir David Brewster supposed, furnished us with pure light and with the intermediate colours of the spectrum. The phenomena recently observed rather indicate that solar light consists of many thousand entirely different vibrations, and we are thus led to regard the solar spectrum in the light of an ascending scale whose vibrations, like those of the musical scale, are arranged with equally definite, though with almost infinitely smaller, intervals.

114. Quitting for the present the subject of the colours and bands of the spectrum, let us attend to the law of refraction at the first and second surfaces of a prism. At the first surface A B of the prism A B C, the ray *d e* falling obliquely suffers a

Fig. 22.



refraction in the direction towards the perpendicular line *e f*. The ray proceeds in a straight line towards the second surface at *h*, and emerging at that point into a rarer medium, is bent,

as formerly explained (article 108) in a direction *h i* away from the perpendicular *h l;* but as in the act of being thus twice bent the ray would be analyzed into its elementary colours, owing to the different refrangibility of these elements, and would consequently become dispersed or expanded, we have represented the ray by a line supposed to indicate the *mean angle of refraction.* Let us now inquire what will be the angles of refraction? The amount of refraction varies in different media; it also varies according to the obliquity of the angle at which the ray meets the refracting surfaces. Snell discovered this fact, but Descartes first announced it as an invariable law, and stated the rule which regulates it. It is a very singular circumstance, and holds good with regard to every variety of media. The law is this: that *at whatever angle the ray is incident, the sine of the angle of refraction bears a constant ratio to the sine of the angle of incidence.* Thus, in the glass prism A B C, the ray *d e* entering at *e*, the sine *m n* of the angle of incidence *d e g* is to the sine *m′ n′* of the angle of refraction as 3 to 2. And again, as the ray emerges into the direction *h i*, the sine *o p* of the angle of incidence is to the sine *o′ p′* of the angle of emergence as 2 to 3. This is called *the ratio of the sines.* For glass it is as 2 to 3, or, as it is generally given in decimals, as 1 to 1·5, as represented in the figure. The *particular ratio of different media* is called the *index of their refraction.* Thus the index of refraction of

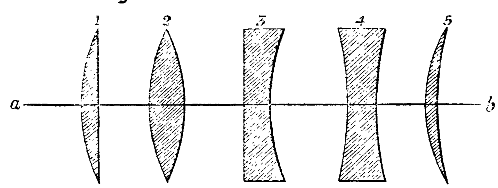
Plate glass is	1·51
Flint glass	1·47
Water	1·33
Diamond	2·47

and so each transparent body has its particular index of refraction.

115. Having considered the refraction produced by the flat sides of the triangular prism, we are now prepared to consider the mode of refraction by curved surfaces, and to describe the prime agent of the optician's art—the lens; that by means of which all his greatest wonders are effected, by

which he is enabled to pierce into the realms of immensity, and by which also he elevates into a world of life and activity a drop of water taken from the stagnant pool. Let us endeavour, therefore, to understand this talismanic agent. As the eye itself is a combination of natural lenses, it is necessary that we should have a clear comprehension of the nature and mode of action of the artificial lens, simple and in combination. There are lenses of various kinds, but we shall enumerate only the following:—

1. The plano-convex.
2. The double convex.
3. The plano-concave.
4. The double concave.
5. The meniscus.

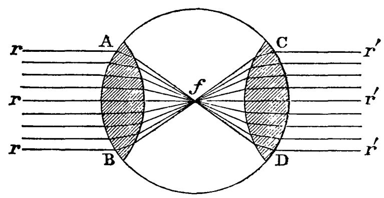


116. The curved surfaces of these are all segments of spheres, being generated by the revolution of circles. The line *a b* passing through their centres is called their axes. Those which have greater thickness at their axes than at their edges, converge parallel and diverging rays to a focus, while those which increase in thickness from their axes towards their edges, cause the rays to diverge or scatter. Let us consider the convex lens. It will be readily understood, that though the rays from a near object radiate on all sides, yet, if we take a remote object, as the sun or a distant landscape, and intercept a few of the rays proceeding from it, they will be nearly parallel. Let us suppose a pencil of parallel rays *r r r* to fall on the lens A B represented in Fig. 23. By virtue of the principles of refraction above explained, the curvature of the two convex surfaces of the lens will converge these separate or individual rays, at least such of them as fall not far from the axis of the lens to a

point called its focus. When the rays which reach the lens are parallel, as in the present instance, the point to which they will be converged is called the *principal focus* of the lens, and the distance of the focus from the lens is called the focal distance.

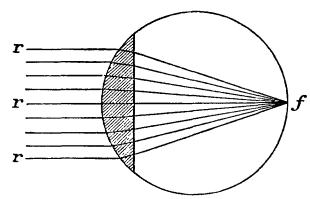
117. The principal focus of a double convex glass lens, whose surfaces are of equal convexity, is, by virtue of the peculiar refrangibility of that medium, a point *f* whose distance is about equal to the radius of the convex surface, as in the annexed figure.

Fig. 23.



118. The principal focus of a plano-convex lens is at a point *f* about the distance of twice the radius of the convex surface.

Fig. 24



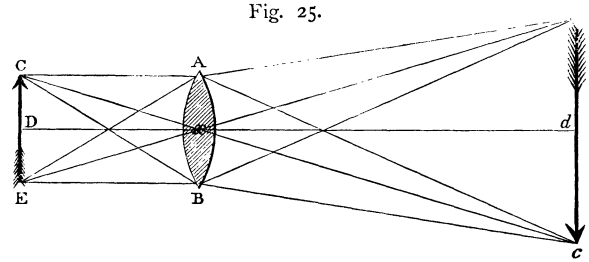
119. The rays, after converging to a focus, cross at that point, and diverge from it at the same angles as they meet; in other words, they diverge from the focus exactly as they radiate from a luminous point, with this difference, that they radiate not in all directions, but in a cone, as represented in Fig. 24.

120. If therefore another lens, C D (Fig. 23), of the same convexity and power as A B, be placed in these rays at the same distance from the focus, it will again refract the diverging cone of rays, and they will emerge from C D in the same state of parallelism at *r' r' r'* as they entered the lens A B. If a candle, therefore, or any radiating object whatever, were placed at this focus *f*, its rays would also emerge in a like parallel state from both the lenses. It is in the proper directing and refracting, converging and dispersing, these cones of light that the optician exercises his talent in the construction of his various optical instruments.

121. The effect, then, of convex lenses is to converge parallel and diverging rays entering them from any luminous or visible point, to a corresponding point on the other side, called a focus. Looking at Fig. 16 it will be seen that every visible point of an object radiates light in every direction. A lens, therefore, held up at right angles will intercept a certain number of such rays. These rays will necessarily fall on it at a vast variety of angles; but by virtue of the laws of refraction before explained, convex surfaces will concentrate those from each part of the object to a corresponding point or focus on the other side, and the result will be that an image of the object will be formed there. If a tolerably large lens be fixed into a hole in the window-shutter of a darkened room, and a piece of white paper be held behind, in its focus, an inverted picture of the external landscape will be thrown on the paper, with all the natural tints of colour—this is the simplest form of a camera obscura.

122. Let us explain this by showing the course which rays from objects take in passing through a lens. Let the arrow in the annexed figure represent an object which is placed at some distance beyond the principal focus of the lens A B, and let us, to avoid confusion, select only the three

Fig. 25.



points C D E of the object; from these and from every point of the object rays diverge in infinite numbers. Let us still further, to avoid confusion, select only those rays which fall on the edges and on the axis of the lens. The rays from C D and E which pass through the centre of the lens at x

will proceed to *c d* and *e* by virtue of the rule explained (articles 106 and 107), without being bent from the straight line. The ray C A, however, which strikes obliquely on the upper edge A of the lens, will be bent down, in the direction A *c*, to the point *c*, and the ray C B, where it strikes obliquely the lower edge of the lens, will be bent upwards, in the direction of B *e*. The rays E A and E B will in like manner be bent respectively in the lines A *e* and B *e*. These are the most divergent rays which could fall on the lens, and we see the lens concentrates them to points or foci. In the same way, obeying the *ratio of the sines*, the rays of light proceeding *from every point* of the object will, by the curved surfaces of the lens, be thrown to their respective foci behind the lens, and an image of the object will thus be formed, which may be received on paper, if the object is a luminous one.

123. The radiant points C D and E, where the arrow or other object is placed, and the corresponding foci *c d* and *e*, are called the conjugate foci; and though there is only one fixed *principal focus*, or *focal distance*, for a lens, namely, the point to which it converges parallel rays, yet it is evident that the conjugate foci will be shifting points; for upon the object being brought nearer, its rays will fall on the lens in a more divergent state, and it will require greater power in the lens to converge them to a focus, and the point at which they are so converged will therefore be removed to a greater distance. Upon our removing the object to a greater distance, the rays on the contrary will fall on the lens more nearly parallel, and the focus of convergence will approach nearer to the lens. The radiant point and the focus will in every case be mutually convertible points: thus, if the distance of the object is six inches, and the distance of the focus or image is three inches, then, if the object be brought to within three inches of the lens, its image will remove to six inches. In Fig. 25, therefore, if C E represent the position and size of the object, *c e* will be the position and size of the image. If,

on the contrary, $c\ e$ be the object, C E will represent the position and size of the image.

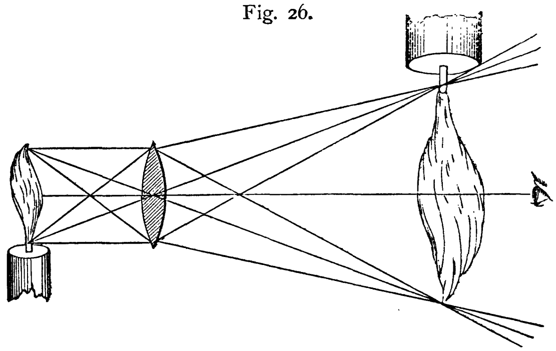
124. If, as before stated, the object be brought into the principal focus of the lens, its rays will stream off in a parallel state, and no image will be formed. If, however, the object be removed back, by ever so little, from the principal focus, its rays will be converged to a point, though a remote one, and an image of the object will there be formed, which may be received on a screen properly placed.

125. Let this be tried. Let us take, for example, a lens whose focal distance is four inches, and let us hold it ten or twelve feet from the flame of a candle, an image of the flame will be thrown upon the palm of the hand, or on a piece of paper held behind the lens at a distance of about four inches. Approach the lens to within four inches of the flame, and no image is thrown on the hand, nor on the wall of the room, nor on any screen wherever placed. Remove the lens a very little farther from the flame, and a distinct inverted image will immediately appear on the wall, and very much magnified. And here we must direct attention to the fact, that in proportion as the object itself, or the image of it, is nearer or farther from the lens, so will the one or other be the larger. If the object is more remote from the lens than the image, then the image will be smaller than the object; but if the object is nearer than the image, then the image will be magnified, and their proportions, dependent on the ratio of the distances, will be always maintained. An inspection of Fig. 25 will explain the reason of this. The rays from an object, while entering the lens at all points, cross the axis of the lens in straight lines, as before explained, without any refraction; the two triangles, therefore, C x E and $c\ x\ e$, are identical in respect to their angles, and proportional as to their respective sides; and therefore, as the sides x C and x E, the distance of the object, are to the sides $x\ c$ and $x\ e$, the distance of the image, so is C E, the size of the object, to $c\ e$, the size of the image; or, holding $c\ e$ to be the object, C E will be its

image. It is important to keep this in view, as on it depends the efficacy of telescopes and of compound microscopes, in a way we shall briefly explain.

126. We have seen that a lens held a little more than the distance of the principal focus from a candle throws a magnified image of it on the distant wall. We can increase this magnified image to any extent by approaching the lens nearer to the object and removing the screen to a greater distance, and throwing the image on it. It is evident that we only see a reflection of the image from the wall. If the eye were placed a few inches behind where the wall

Fig. 26.



or a screen is placed, the diverging cones of light (represented in the annexed figure) from the extreme upper and under parts of the flame, owing to the large size of the image and the small size of the pupil, would not enter the pupil of the eye placed behind—a few only of those from the centre of the image would enter the eye; we should therefore not see the whole image of the object. If, however, we had a lens sufficiently large to receive all these diverging cones of rays, and to bend them so that they crossed in a parallel state in bands, crossing at one circumscribed point, the eye placed at that point would receive them, and a magnified image of the candle, of great brightness, would be perceived. We shall, however, explain the principles of simple and compound microscopes a little more systematically in a subsequent page.

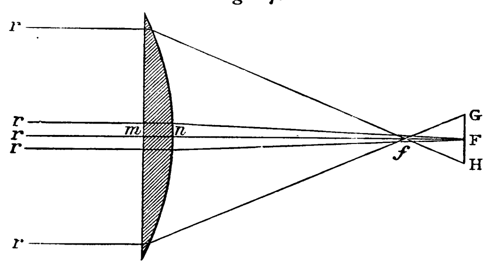
If the principles of refraction, as above explained, be fully understood, little difficulty will be found in understanding the principles of the construction of optical instruments and of vision.

127. Though a camera obscura (such as we have described in article 121) gives a very vivid representation of the external landscape, yet the application of various additional contrivances is necessary to render it a perfect instrument. In the *first* place, the true form which the picture or image assumes, as cast by the convex lens, is a concave sphere nearly corresponding to the curve of the lens. The image or picture cast ought, therefore, to be received, not on a flat surface, such as a piece of paper, but on a concave spherical surface; and if this is done it renders all parts of the picture more distinct. *Secondly*, it is evident (from the explanations given, articles 124 and 125,) that the images or foci of the more distant parts of the landscape will be formed nearer the lens, while the images of the nearer objects, from which the rays are more divergent, will be formed further back from the lens; the paper for receiving the image cannot, therefore, be placed to suit at the same time both the nearer and the more remote parts of the landscape, but requires to be shifted backwards or forwards, according as we wish to bring out one or the other part of the landscape more clearly. There is another way in which the focus or image may be adapted for the nearer and more distant parts of the landscape, viz. by transmitting the rays through a second lens, by shifting which the focus can be adjusted to the different parts of the landscape.

128. A *third* cause of imperfection in the image thrown by the single convex lens, whose surfaces are segments of spheres, arises from a law of refraction which we have already explained. By tracing the line of refraction through spherical surfaces, on the principle explained in article 114, it will be found that the refraction of those rays which fall on or near the centre of the convex lens are converged to a focus at a somewhat greater distance from the centre of the lens than

those which pass through the parts nearer the edges, where the convergence to the focus is more rapid. The plano-convex lens, with its plane side towards the parallel rays *r r r r r*, is the form and position which produces the greatest amount of spherical aberration. Thus, in Figure 27, F is the focus of the central parts of the lens, and *f* the focus of the rays from the extreme margins; the distance of these two foci, F and *f*, is the measure of what is called the longitudinal spherical aberration; and G H is the lateral spherical aberration. In a plano-convex lens, placed as in the figure,

Fig. 27.

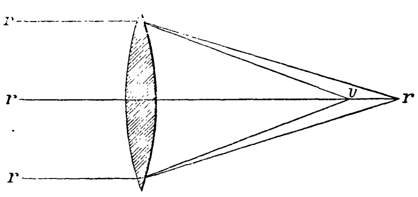


the longitudinal aberration will be $4\frac{1}{2}$ times *m n*, the thickness of the lens. Had the convex side of the lens been turned towards the parallel rays *r r r r r*, the aberration would only have been $1\frac{17}{200}$ part of its thickness. Between those two foci, F and *f*, the lens produces, mathematically speaking, not one image of an object, but an indefinite series of images or foci of each point of an object, ranged one behind the other. From this cause an image of any object cast by such a lens must possess a certain amount of indistinctness, from the blending of the different foci or images. The cure for this defect in the spherical lens would be to give greater convexity to its central parts, and diminish this convexity gradually towards it edges—in fact, to make the lens not spherical but elliptical. This would remedy the evil, but hitherto it has been found impossible to grind and polish surfaces of this shape; and therefore lenses for optical instruments, notwithstanding the objection to them, are still made with

spherical surfaces, and the evil, though not entirely obviated, is at least diminished, by inserting a diaphragm, cutting off the rays flowing through the edges of the lens.

129. *Fourthly*, there is a still more formidable imperfection in the image thrown by any single lens, of whatever shape, the nature of which will be understood by those who recall to mind that colourless light is composed of the united elements revealed in the prismatic spectrum, and that a ray of light, by being subjected to refraction, is necessarily separated into its elementary colours in the order of their refrangibility. Now, the lens may be looked upon as a combination of prisms, and as its object is to deflect the ray out of its natural course, it must necessarily cause a separation of the prismatic colours. It is accordingly found that the violet rays, being the most refrangible, are converged to a focus at *v*, nearest the lens,

Fig. 28.



while the foci of the other rays follow in the order of their refrangibility; the red rays, being the least refrangible, are converged to the remotest point, at *r*. These rays therefore form so many different coloured images of the landscape or other object, which range themselves behind one another, and thus produce a certain indistinctness and an unpleasant coloured effect. And though the blending of these different colours, by their superposition one on the other, in part destroys the prevalence of any specific colour except the extreme rays, yet, as the paper can only be in the focus of one colour at a time, the greater vividness of that colour will then prevail, and the prismatic hues arising from the stronger lights of the landscape being scattered over the darker parts,

will produce considerable confusion in the picture. This defect results from what is called *chromatic aberration;* and, in the construction of telescopes and microscopes, the obviating of it becomes a matter of the greatest importance and, as may be supposed, of consummate difficulty.

130. In Newton's time the evil was well known, and the cure was by him considered impracticable. He had been employing himself in the grinding of optical glasses of other figures than spherical, in order, if possible, to obviate the spherical aberration, when, on experimenting on a ray of light with the glass prism, he made the important discovery of the composition of light, and the different refrangibility of the different primary rays. His account of this and his other principal discoveries on light is conveyed with his usual clearness and simplicity in his well-known letter, dated at Cambridge, 6th February, 1671, addressed to Mr. Oldenburgh, at that time secretary to the Royal Society. When he had, by varying his experiments, satisfied himself that each primary colour had its own refrangibility, he despaired of gaining the object in view—of combating the chromatic aberration produced by optical instruments. "When I understood this," says he, "I left off my aforesaid glassworks; for I saw that the perfection of telescopes was henceforth limited, not so much for want of glasses truly figured according to the prescription of optic authors, which all men have hitherto imagined, as because that light itself is a heterogeneous mixture of differently refrangible rays; so that were a glass so exactly figured as to collect any one sort of rays into one point, it could not collect those also into the same point which, having the same incidence upon the same medium, are apt to suffer a different refraction." Newton was not aware that different kinds of glass possessed different dispersive powers, or his keen eye would not have allowed the fact to pass unimproved, and he would doubtless have added to his other honours that of having achieved one of the greatest practical improvements in the construction of optical instruments, the correc-

tion of chromatic aberration. To prevent any disparagement to him on this score, though in the reader's mind a sentiment of regret will still remain, it appears that, in the progress of his experiments, he approached, at one time, the very threshold of the discovery, but was prevented reaching it by a circumstance purely accidental; for, while counteracting the refraction of a ray of light through a glass prism, by an inverted prism of water, he had unluckily mixed sugar of lead with the water to increase its refraction. Had he used a prism of pure water, he would in all probability have been led to the highly important discovery which he was in search of. It was reserved for Mr. Hall, a gentleman of Worcestershire, to rectify Newton's mistake, and to apply his discovery to the construction of an achromatic telescope.

131. The human eye has generally been believed to be a camera obscura of the most perfect kind, in which all the difficulties and imperfections above enumerated, as belonging to artificial cameras, are successfully obviated, and in which a true figure of external objects is thrown on the sentient expansion of the optic nerve, seated at the bottom of the eye. This, however, is not strictly the case. Having endeavoured to point out some of the excellences of the eye as an organ of vision, and some of the difficulties with which it has to contend, we shall now indicate certain of its defects. If we look for perfection in any physical structure we shall look in vain, for even the sun has its spots. As, however, it requires the telescope to discover the blemishes of the central orb of our system, so it requires the genius of a Helmholtz to convince us of the defects of an organ which all the hours of our waking life we are using, not only without inconvenience, but with conscious benefit and comfort.[1] We do not intend to dwell on this side of the picture, but merely to listen to what ingenuity may be able to say in dispraise of an organ generally believed to be perfect.

[1] "Popular Lectures on Scientific Subjects." By H. Helmholtz. Translated 1873.

132. First, then, as to chromatic aberration. The eye has positively not the means of correcting this aberration; the images focused by the more luminous rays, namely, by the yellow, green, and blue, are usually focused upon the retina without much perceptible aberration; but the aberration of the extreme rays, the red and the violet, the eye cannot correct so as to cause the images they cast to coincide either with one another or with the middle rays. We may convince ourselves of this by employing a glass coloured with cobalt oxide, which allows the red and blue rays to pass, but stops the green and yellow rays. On looking through such a glass at a distant street lamp we see a red flame surrounded by a bluish violet halo, this is the dispersed image formed by the red and blue or violet rays of the object. The eye is, therefore, not an achromatic instrument; fortunately, however, the extreme rays being the least luminous, the dispersed images they cast on the retina are no serious inconvenience to vision.

133. Second defect—regarding spherical aberration. Although the elliptical form of the crystalline lens, and the supposed increased density and refractive power of its nucleus, added to the operation of the iris in cutting off the more divergent rays, is believed to reduce the evils of spherical aberration to a minimum, yet Helmholtz asserts that this evil is seldom corrected owing to the frequent irregular curvature of the cornea and crystalline lens.

134. Third. Another defect most persons are conscious of. In looking at a star, or at the new moon, the former appears not as a luminous point, but as a dazzling cluster of rays; and the latter, to many persons, appears double or threefold. This, according to Helmholtz, is owing to the construction of the crystalline lens, the fibres of which are arranged round six diverging or radiating axes, which displaces the rays.

135. Fourth. Another defect is the want of perfect transparency in the substance of the cornea and in the crystalline lens; this produces a dullness in the perception of pure blacks

and whites; and this species of defect is increased by what is called fluorescence, when the blue and violet rays of the solar spectrum enter the eye.

136. Fifth. We may state the existence of the blind or insensible spot where the artery and optic nerve enter the eye-ball.

137. Sixth. Not to be too minutely critical, we shall finish by alluding to what few persons are conscious of. When we go into a dark room, and cause a small lighted taper to move in different directions, obliquely, at the outer edge of the eye we may perceive certain dark red branching lines, called Purkinge's figures; these lines are, in fact, the shadows of the blood vessels which traverse the anterior layer of the retina, which—being cast on the sensitive part of that membrane which lies below, the purely subjective objects of which we are thus rendered conscious—deceive us by appearing as if they were external realities.

Our next chapter will consider the eye both as an optical instrument and as a physiological organ.

CHAPTER XIV.

LIGHT AND VISION.

THE HUMAN EYE—THE FUNCTIONS OF THE RETINA—MODERN DISCOVERIES.

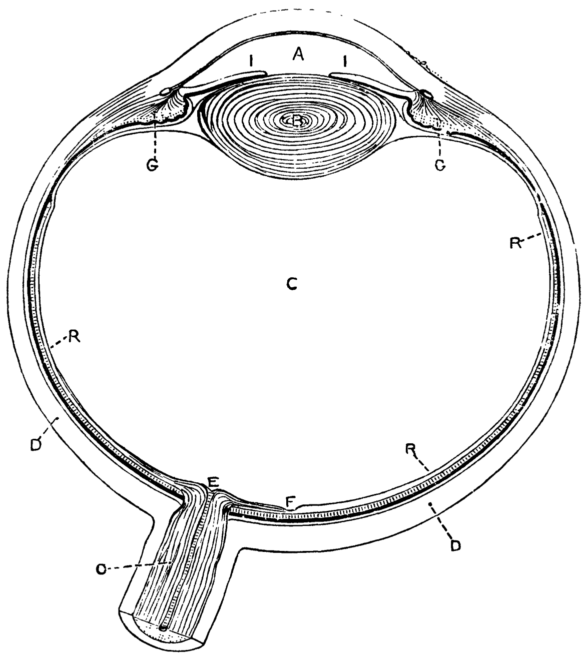
138. THE human eye, viewed as an optical instrument, is a combination of three lenses, enclosed in a globular case or sac.[1] By means of these an image or picture of external objects is thrown on the sensitive ganglionic terminations of the expansion of the optic nerve, called the retina, which lines the bottom of the globe of the eye, and the sensation of light is thus produced.

139. Fig. 29 is a diagram representing a horizontal section of the right eye. It is perfectly spherical internally, except at the fore part, which is considerably more prominent. The globe of the eye is divided into three principal chambers, which contain three transparent humours, namely, the aqueous humour A, the crystalline lens B, and the vitreous humour C. These are all enclosed in a spherical case, consisting of four coats, or membranes. The outer one D, forming the white of the eye, is called the *sclerotic coat*, from σκληρος, hard, tough; and any one who tests this quality will be convinced that the name has been well applied, as it is with difficulty we get the sharpest instruments to make an impression on it. This coat extends round the back parts of the eye; it is opaque, or nearly so, and is united to, or merges into, the *cornea*. The cornea is the transparent covering of the fore part of the eye. It consists of several firmly adhering layers, and being exceedingly tough, and

[1] Some hold that there are four lenses, the cornea being considered the first lens, and the aqueous humour the second, and it is no doubt probable that the rays suffer a refraction at entering the surfaces of each of these substances; but till we know more of this we shall hold there are but three lenses.

slightly movable or yielding, owing to the fluid humour lying beneath, it seems as well fortified from external injury as so delicate and transparent a substance can possibly be. Within the sclerotic coat lies the second coat, called the *choroid.* This coat is of a more soft and delicate nature, and forms a complete lining to the sclerotic, not, however, extending so far forward as to encroach on the transparent cornea. It is

Fig. 29.



covered on its inner surface by black pigment cells. Immediately within this pigment, and immersed in it, lies the retina R R R, which is the third or innermost coat. The optic nerve O enters the eye and, expanding over its back surface, forms the retina.

140. The retina appears as a delicate reticulated membrane, but is found, on microscopic examination, as we shall afterwards see, to be a very complex structure. The *fovea centralis*, or most sensitive portion of the retina, is marked F·

and of it we shall hereafter have to speak. The retina lines the whole of the posterior part of the eye, from R to R, nearly as far forward as the plane of the crystalline lens. The transparent humours already enumerated entirely fill the round case formed by these coverings.

141. The anterior of the cornea approaches in shape a meniscus, with its convex surface towards the light, and the concave side next the crystalline lens. The aqueous humour consists chiefly of pure water, holding a little muriate of soda and gelatine in solution, with a trace of albumen, the whole not exceeding eight per cent. Its refractive index is accordingly almost precisely that of water, being 1·337, while water is 1·336. This humour fills up and gives prominency to the cornea, which thus, it has been held, assumes the form so much aimed after by opticians, but hitherto unattained in the formation of artificial lenses, that of the ellipse, according to M. Chossart's calculations. The elliptical surface forming the transparent front of the eye is exactly such as would converge to a focus with mathematical exactness all parallel rays incident in the direction of the axis of the eye. The spherical aberration which would have existed had the external surface been of a spherical figure, is thus, in a perfectly formed eye, destroyed for parallel rays entering in the direction of the axis; and the aberration of those entering in an oblique direction is diminished, or corrected by the varying density of the crystalline lens, as shall be afterwards explained.

142. At the back of the chamber containing the aqueous humour is the iris I I, which is a circular opaque screen, or diaphragm, by whose contraction and expansion the aperture, called the pupil, is diminished or extended, so as to regulate the amount of light admitted to the retina, for the purposes of comfortable vision. Under strong light the pupil is much contracted, so as not to exceed $\frac{12}{100}$ of an inch; while in feeble illumination it dilates to double its ordinary diameter. This contraction of the pupil is the result of the stimulus of

the light—a beautiful piece of self-adjusting mechanism, as Sir John Herschel justly observes. It is this expansion of the pupil which renders the eye so much more dark when seen in the shade, than when exposed to the full light of day.

143. The iris is that circle whose colour marks the distinctive character of eyes as being blue, gray, brown, or black. Immediately behind the iris is posited the crystalline lens. It is suspended in a transparent capsule by the ciliary processes, which are attached to every part of its margin. According to Sir David Brewster, its shape is that of a convex lens, whose anterior surface is much less convex than the posterior, the radius of the former being 0·30 of an inch. and that of the latter surface only 0·22. The crystalline lens is a much more solid substance than either the aqueous or vitreous humours. It contains a much larger proportion of albumen and gelatine, in consequence of which it becomes entirely coagulated by the heat of boiling water, as the reader may have observed is the case with the crystalline lens of fish brought to the table. Its superior density gives it a correspondingly high refractive power; and it is worthy of remark, that its density is greatest in its centre, and decreases towards its surface and margin. The refractive index of its centre is, according to the authority just referred to, 1·3990. The mean between that and its surface is 1·3839, and its surface is 1·3767. The advantage of this increasing density towards its centre will be apparent to those who recall what was said (art. 133) regarding spherical aberration.

144. Immediately behind the crystalline lens is the vitreous humour which fills up the whole posterior chamber of the eye. This humour differs but little in chemical composition from the aqueous humour; its refractive power being nearly the same, viz. 1·3394, while that of the aqueous humour is 1·336. In volume it exceeds both the other humours put together, constituting the great bulk of the globe of the eye.

145. Such is the structure of the eye, described as an

optical instrument. The humours, with their convex surfaces acting as lenses, receive the rays proceeding from near and distant objects, and concentrate them into a focus within the bounds of the eye. Each point of the external object is thus represented by a corresponding point on the retina, so that an image, true in colour and shape, is projected in an inverted posture on the concave surface of that nervous expansion.

146. The apparent size of the object depends on the space its image occupies on the retina, and this again depends on the relative distances of the object and of the retina from that part of the axis of the eye where the rays cross, as we have explained in article 125. Thus, if this point in the eye is nine-tenths of an inch from the retina, a man six feet high and half a mile distant will be represented on the retina by an image little more than the $\frac{1}{500}$th part of an inch in length.

147. The eye has, as we have explained, a certain power of adjusting itself so as to increase its refractive power for near, and diminish it for distant objects. This power is, however, limited; and the nearest distance at which minute objects can be distinctly seen by most eyes is from four to six inches. On attempting to examine small objects nearer than this, the eye becomes immediately aware of an uneasy strain; and if the object is brought nearer, a hazy indistinctness is the result.

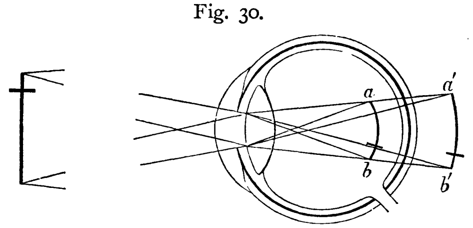
148. While there is thus a limit to the nearness at which the eye can exercise its powers, there is no impediment to its power of viewing distant objects. All objects, however distant, provided they emit sufficient light, and subtend a sufficient angle, are distinctly visible. We may mention the moon as a case in point. The outline of its figure is as distinct to our eyes as any object which, subtending the same angle, is only a few feet distant.

149. It may be stated, that all eyes possessing ordinary vision have the power of converging parallel rays, and even rays that do not enter the eye at an angle of divergence

exceeding three or four degrees. Many eyes are, however, defective: some are short-sighted, that is to say, minute objects cannot be distinctly seen without being brought close to the eye. This arises from the too strong refractive power of such eyes, owing either to over-convexity in form, or to over-density in the humours of the eye. The rays from distant objects are, from either of these causes, too soon converged to a focus, as in Fig. 30; and the image therefore does not fall upon the retina, but on a point before it at *a b* The only *natural* remedy such a person has is to bring the object towards his eye, when, according to the principles explained (art. 125), as the object approaches, the divergency of the rays entering the pupil increases, and the focus, or image of the object proportionately retires towards the retina. Another resource is in the use of spectacles with concave lenses: these give greater divergence to the rays flowing from the object, and thus counteract the refractive power of such eyes.

150. Aged persons and many others have eyes deficient in refractive power. They hold the book they read at arm's length, in order to get the rays to enter the eye as little divergent as possible. Their eyes are unable to overcome the

Fig. 30.



divergence of rays from near objects; and these rays accordingly tend to a focus behind the plane of the retina, as represented in the figure at *a' b'*. The defect in the refractive power of such eyes is therefore assisted by the use of convex spectacles.

151. Nearly every optical instrument requires an altered adjustment for near and for distant objects. The opera-glass

demands a constant shifting of the eye-piece. In using the microscope there is no difficulty, for we place the object so that it may be in the proper plane to suit the requirements of the instrument, and of the observer's eye. With regard to the eye itself, it requires adjusting for every act of vision, the retina being a fixed screen on which the images of all objects, whether they be near or distant, have to be correctly formed. What is the contrivance by which this is effected? This was long a problem. Sanson, however, made a discovery which led to the settling of the question. He oberved that in looking into the eye there were three visible reflections of every small bright external object.

The first was from the surface of the cornea. The second was from the anterior surface of the crystalline lens; and the third was an inverted image reflected from the concave posterior surface of the lens. Langenbeck found that the size and relative positions of these reflections altered according as the eye was accommodated to near or more distant objects. Cramer and Helmholtz made this shifting of the reflected objects the subject of minute observation; and by the use of an ingenious instrument, the *ophthalmometer*, they were enabled to determine not only that the shifting is owing to a change in the curvature of the crystalline lens, they also ascertained the extent to which this change is practicable. As the crystalline lens consists of concentric coats, and as these coats are composed of serrated fibres, but possess neither nervous nor muscular fibres, it was not apparent how this action of the lens was brought about. It is now, however, believed that the increased curvature is effected by the ciliary muscle which forms a continuous zone round the edge of the lens, and thus exerts either a pressure or a traction on it, and alters its curvature as may be required.

152. Having shown how a correct image of external objects is focused on the retina, we have now to explain the very singular provision which microscopic investigations have shown to exist in the structure of that delicate membrane for

utilising the retinal impression, and for its transmission to the sensorium. The special contrivance for accomplishing this cannot fail to add to the admiration with which the organ of vision has always been regarded.

153. In explaining the theory of vision in consistence with recent histological discoveries, it may be more instructive to present the subject in the form of a reasoned statement than to give the mere conclusions ; we shall therefore transcribe, in an abridged form, a paper intended to have been read in April, 1873, to the Royal Society of Edinburgh, "On the Functions of the Rods and Cones, and the Nerve Fibres of the Retina."[1]

154. The popular, and indeed the all but universal, opinion regarding vision was that the retina was a membrane, over which was ramified the fibres of the optic nerve ; that the inverted image of external objects was cast on this membrane, and that the nerves, acted on by the stimulus of light, transmitted the impression of the retinal image to the brain.

155. This explanation of the case, which has satisfied us since the days of Newton, has lately been surmised to be

[1] The author had announced a paper on this subject to the Society on the 21st April, 1873; but almost immediately after preparing and handing it in for approval, the translation of Helmholtz's Popular Lectures on Scientific Subjects, which had been published in March, came into his hands, and he at once discovered that his conclusions had been anticipated by that master in physics and physiology. Helmholtz in this volume, in a few words, assumes the connection of the nerve fibres with the cones and rods, and the insensibility of the nerve fibres to light, a point which the author of the paper referred to endeavoured to establish by deductive reasoning. Helmholtz's remarks are these :—

"The nerve enters the apple of the eye from behind, rather to the inner nasal side of the middle of its posterior hemisphere. Its fibres then spread out in all directions over the front of the retina. They end by becoming connected, first with *ganglion cells and nuclei*, like those found in the brain ; and, secondly, with structures not elsewhere found, called *rods* and *cones*. The rods are slender cylinders; the cones, or bulbs, somewhat thicker, flask-shaped structures. All are ranged perpendicular to the surface of the retina, closely packed together so as to form a regular mosaic layer behind it. Each rod is connected with one of the minutest nerve fibres, each cone with one somewhat thicker. This layer of rods and bulbs (also known as *membrana Jacobi*) has been proved by direct experiment to be the really sensitive layer of the retina, the structure in which alone the action of light is capable of producing a nervous excitation."—*Popular Lectures.* By H. Helmholtz, pp. 207, 208. Translated 1873.

insufficient. We shall first then show in what respects the popular theory is an incorrect theory, and we shall then offer an explanation which will satisfy all the requirements of the case.

156. When we consider that the purpose of the organ of vision, and especially of the retina, is not merely to convey to the mind the peculiar sensations of colour, but to present also to the mind the exact forms of the external objects which are cast upon it, the question how this is effected becomes evidently one of high interest. It is also one of extreme difficulty. Indeed, until recent discoveries were made regarding the singular structure of the retina, it was a question which could not possibly be answered aright. So far as we have seen, it does not, however, appear that the extent of the difficulty has been fully acknowledged by writers on the subject.

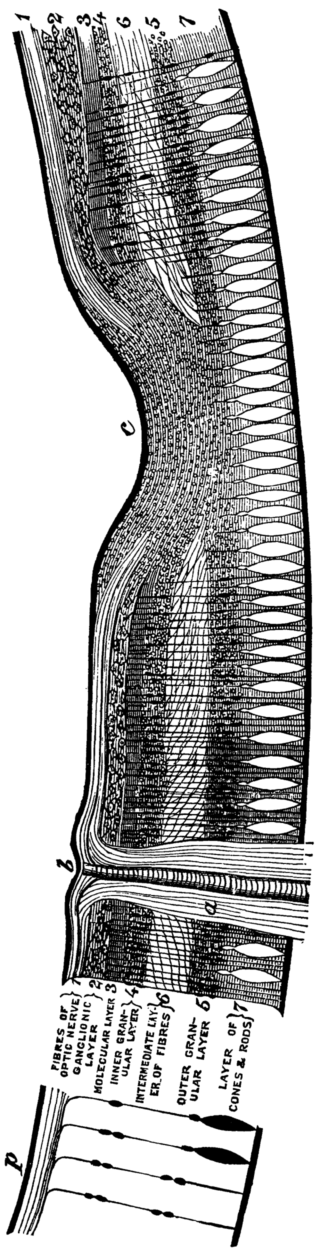
157. The question is this: How is vision possible in connection with the peculiar arrangement of the fibres of the optic nerve, which are ramified over the surface of the retina? In answering this we shall show that modern histological investigation has revealed to us a new anatomical structure, and enabled us to see with what surprising skill the retina is framed for the purposes of vision.

158. First, let the reader remember that it is a well-known principle that in whatever part of a sentient nerve an impression is made, we refer the sensation to the *extremity* of the nerve. As a familiar instance, when we receive a stroke on the nerve at the elbow joint, we all know that the sensation is not felt there, but all over the palm of the hand.

159. In the second place, let it be remembered that whatever may be our sensations or inferences to the contrary, it is now pretty generally admitted that visual perception, as well as all our other sensations, is not really located in the external organs of sense, but in that part of the brain to which the nerves carry the impressions. (See chap. xviii.)

160. Having premised thus far, we now present a section

Fig. 31.



of that part of the retina which contains the *punctum cæcum*, where the optic nerve *a* and the artery *b* enter the eye-ball, and where the most sensitive parts of the retina, namely, the *macula lutea* and *fovea centrales*, are represented at F, in Fig. 29, and at *c* in this figure.

161. The retina, which is probably not more than the thickness of a sheet of ordinary printing paper, is described as divided into layers. Beginning at the anterior surface we have (1) the close net-work of the optic nerve and fibrils spread over the surface. Next below (2) is a layer of nerve cells, or ganglia, most of them provided with two or more processes.

Next to these (3) is a fine molecular substance; and below this are (4 and 5) the anterior and posterior granular layers, separated by an intermediate layer of fibres (6).

The lowest layer (7) is the columnar layer, or layer of rods and cones.

Throughout the anterior layers the branches of the blood-vessels which nourish the membrane are ramified. Throughout the retina are also discovered numerous fibres running across it in a vertical direction, except

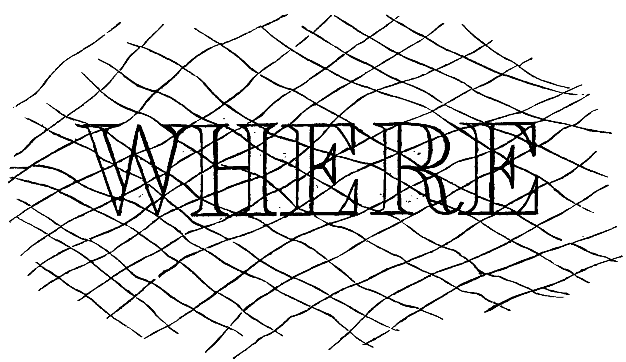
where they approach the region of the *macula lutea*, where they are said to assume a horizontal direction. The connection of these fibres with the cones and rods has not yet been established, and it has, in fact, been generally denied by our writers.

The next point of importance is this, that in the *macula lutea* the cones become more numerous than the rods, and in the *fovea*, the rods disappear, and their place is entirely occupied by cones, which are here packed closely together.

162. As we approach the *macula lutea*, all the layers and also the blood-vessels seem to thin off, except the granular layer and layer of cones.

163. Having given this description of the retina, let us for a moment suppose, as was long erroneously done, that it is through a susceptibility to light, possessed by the fibres of the optic nerves, that they *convey* to us the impression of the retinal image. Is it not evident that such a supposition entirely misleads us? for in order to enjoy vision it is essential that each nerve fibre should be affected at only one point, and should transmit to the brain the impression of only one point of the image. To make this apparent, let us suppose the annexed figure to represent a portion of the retina,

Fig. 32.



and the lines to represent the fibres of the optic nerve which traverse it, and on which the image of the word WHERE is cast. It is evident that these fibres, if they were sensitive to light, could yield the mind no impression of the image cast

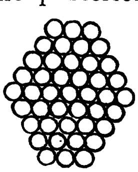
on them, because they are acted on, not at one point only, but at the several points where the letters impinge on them It would be a physical impossibility, then, in such circumstances, that they should transmit to the brain an impression of the thickness, distance, and direction of the different parts of the several letters. Each fibre could transmit evidently only one cumulo-impression of the various impulses made on it, however numerous these impulses might be; and therefore, as we have said, if the optic fibres spread over the surface of the retina were sensitive to light, vision would be impossible. And yet it has for many years been supposed that it was owing to the sensibility of these fibres that we enjoy vision.

It is satisfactory to know that while modern writers have arrived at the conclusion that the nerve fibres are insensible to direct light, from observing that the part of the retina where the optic nerve enters the eyeball is insensible to it, the same conclusion can be established on physiological and optical grounds.

164. The opinion had been gradually gaining ground, that it was by the instrumentality of the cones and rods, in some way or another, that sensibility was given to the nerves; and it was surmised that, though the fibres were insensible to light as it passed down through them, they became sensible to it as it passed up from the cones and rods, which were supposed to have had a power, in some way, of modifying the light so as to enable it to affect them.

165. This view was evidently absurd; for, as we have shown, if the nerves were sensitive to light either when it fell on them from above, or when it was reflected on them from below, vision would be impossible.

166. The true function of the cones and rods is apparent. These curious bodies stand close together on the posterior surface of the retina, and as they point directly forward towards the light, when we look down upon them in the microscope they have the appearance, as it were, of a close pavement, as here represented.



167. Here, then, we have a wonderful arrangement for receiving the impression of the retinal image. And, in order that each cone may transmit the impression that falls on it, we must assume that these bodies are no other than sensitive ganglionic terminal expansions of the nerve fibres. As the light then streams down through them, we cannot fail to see how admirably in every respect is their position for receiving the impressions from each minute point of the retinal image, and also for their being acted on by the light which, as it passes through them, must stimulate them throughout their entire length, and cause them to discharge the nerve force which is thence to be passed to the brain.

168. To hold, as has been done, that these important sensitive parts of the retina are destitute of connection with the nerve fibres is as inconsistent as to hold that we may see and hear without the appropriate organs.

If nerve fibres have not been discovered in connection with these conical bodies, is it not more reasonable to assume that, owing to their extreme delicacy, they become decomposed immediately after death by the action of the surrounding parts, than that they do not exist?

It may, we think, be safely concluded—

1st. That the apparent thinning off of the nerve fibres and other layers at the *fovea* is in order that this most important part may not be encumbered by the passage of nerve branches or blood-vessels across it, and that the light may have free passage to the cones.

2nd. That both from experiment and from deductive reasoning, we are entitled to hold that the nerve fibres are insensible to light, except at their conical terminations, and that their function is confined to the simple transmission of the nerve influence discharged by these terminal ganglia.

3rd. We may either hold that the specific nature of the nerve stimulus discharged by the cones (and which determines the sensational *colour*) depends solely on the nature of the vibrations falling on them ; or it may be that each specific

vibration, say, of red, yellow, blue, etc., affects only such of the cones whose particular length may make them subject to that special luminous vibration, as Helmholtz suggested to be the case with reference to similar organs in the ear.

169. In conclusion, let us remark that the functions and arrangements of the different parts of the retina—the insensibility of the nerve fibres—and the existence of special sensitive conical terminations, contrived and placed so as to subserve so remarkably the purposes of vision, cannot be studied without calling forth the liveliest feelings of interest and wonder.

CHAPTER XV.

VISION (*Continued*).

SIZE OF OBJECTS—NATURAL PROCESS OF MAGNIFYING—ARTIFICAL MEANS —BY AN ARTIFICIAL PUPIL—BY THE SIMPLE LENS, IN TWO WAYS—BY COMBINATIONS OF LENSES.

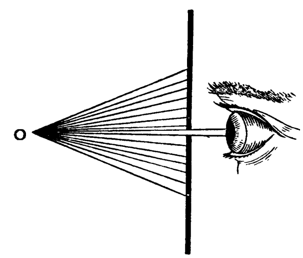
170. WHEN we wish to examine a distant object, we have a ready resource at our command,—we walk towards it. By so doing we find that its various parts gradually unfold themselves. We adopt the course of approaching the object naturally, or rather as the result of experience, but we probably do not consider that the end attained is the magnifying of the object, and that this is the sole cause of the increased distinctness. As our distance decreases to one-half, one-third, one-fourth, the angular size of the object successively increases in the like inverse proportion, and the apparent bulk of the object, *i.e.* the area which its image occupies on the retina, increases as the squares of these numbers, namely, to four, nine, and sixteen times the original apparent size.

171. Suppose, however, the object is a flower which we wish to examine more carefully, we still continue the process of narrowing the distance between the eye and the object. By-and-by, however, we find that there occurs a certain point within which we cannot push this process of magnifying; for when, with a view of examining some minute part of the structure, we bring it as close as possible to the eye, we find that vision rapidly becomes indistinct. The distance at which ordinary eyes can best view minute objects is, as we have formerly stated, about six inches; but this varies greatly with different individuals. Short-sighted persons are able to examine small objects, and to read at four or five inches;

while others, who are long-sighted, hold the object at arm's length, say thirty inches from the eye,

172. It appears, then, that there is a natural limit to our powers of examining small bodies, and the cause is this: when we bring the object too near, the divergence of the rays from it becomes so great that the lenses of the eye are unable to converge them to a focus upon the retina. Knowing the cause of the obstacle, a simple remedy suggests itself. If we take a slip of card and perforate it with a small pin-hole, and examine the object through this narrow orifice, we find that whereas when using the naked eye we were obliged to hold the object about four inches distant, we can now distinctly examine it, perhaps so near as one inch from the eye. In this case, being brought four times nearer the eye, its angular size is increased in the same proportion. The card, it will be seen, cuts off all the extreme divergent rays, and allows only such as are nearly parallel to enter the pupil, and these the refracting humours of the eye are able to converge to a focus.

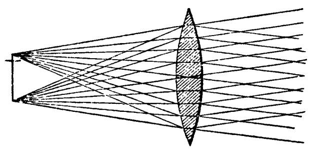
Fig. 33.



173. This card is a microscope of the simplest kind. A formidable objection, however, to it is that it allows few rays to enter the eye, and great obscurity is the result; for practical purposes, therefore, we must look for some other contrivance, and this we find in the convex lens. In using this instrument the object is placed in the focus of the lens, and when in this position the rays coming from it will, as formerly explained (art. 117), emerge parallel and fitted for the eye, converging them to a focus on the retina. If a, lens, therefore, of an inch focal length, be held in this way, the eye, placed in any part of the parallel rays which stream from it, will see the subject magnified as much as was done by the card; but as the pupil when using the lens is permitted to

receive all the rays that can enter it, much greater clearness is obtained. Such is the simple microscope, whose sole efficacy consists in this, that it enables us to examine objects much closer than can be done by the naked eye. If the naked eye will only permit of an object being examined at a distance of six inches, and the interposition of a lens enables us to examine it at a distance of half an inch, the object will appear magnified twelve diameters, and its bulk will be increased 144 times. By using a single lens of sufficiently short focal length, the animalcules in a drop of water may be distinctly observed, the only difficulty is to get the objects fixed at the necessary distance from the lens.

Fig. 34.

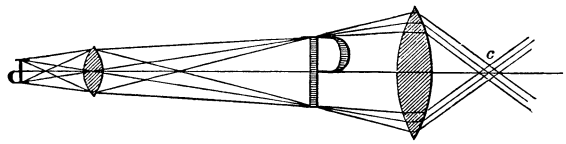


174. The simple lens possesses also a power of magnifying in a different way from that just described; namely, by throwing an enlarged image of the object into the air, in which position the eye, properly placed behind it, may view the enlarged image as if it were a real object. Take a lens, say of about one inch focal length, and hold it a little farther than its focal distance from the small print of a book, the letters, so long as the eye is held near the lens, will be quite undistinguishable; by drawing the head, however, a little further back, suddenly, a single letter, having amazing brightness, will seem to start into existence and to float before the eye. It will appear in an inverted position, and so enlarged as to occupy perhaps the whole surface of the lens. This is the image of the letter formed in the air, and which, like any real object, becomes visible so soon as the eye is five or six inches behind it, so as to see it distinctly.

175. If now, when conducting the above experiment, we fix the lens steadily in its position, and take another lens of a larger size, and of greater focal distance, and hold it at a distance behind the image, so that the image is brought into its focus, as exhibited in the subjoined figure, the cones

of light diverging from the image will be received by the larger lens, which will overcome their divergence, and cause them to emerge in a parallel state. The eye, therefore, placed

Fig. 35.

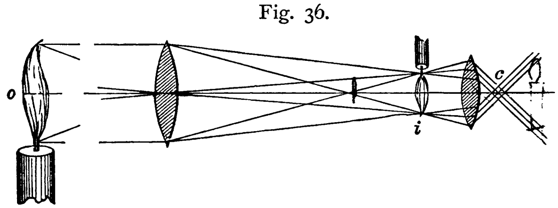


behind it at the point *c*, where the rays cross, will perceive the inverted object in a very distinct and greatly enlarged form. The instrument which we have constructed with so little ado is the *compound microscope.*

176. The principle on which the magnifying power of such instruments is estimated, is this : Suppose that the first lens or object-glass is held so that the image it forms of the object is six times the distance behind the lens that the object is before it, the image will in this case have a diameter six times the diameter of the object (art. 126) ; but as this image cannot be viewed by the naked eye nearer than six inches, the benefit of a second lens becomes apparent. Suppose this second lens to have a focal distance of two inches, it enables us to view the image at that distance, or three times nearer; the object will therefore, in the case supposed, be magnified in all eighteen diameters, or in bulk 324 times.

177. Having explained the principle of the compound microscope, let us next see whether we can with equal facility

Fig. 36.



form a telescope. Let us take the same two lenses in hand, but in the present instance let us hold the larger lens before

us in the left hand, as an object-glass, and look through it across the room at a candle, and let us take the smaller and more powerful lens in the right hand and apply it to the eye as an eye-glass; by now shifting the remoter lens backward and forward we will soon be able to adjust it to the proper position, and will be surprised to find the candle brought nearer us, but in an inverted position. This arrangement of the two lenses is precisely that of the instrument known as the *astronomical telescope;* and it was by means of such an instrument, though with a greatly larger object-glass, that Huyghens discovered the ring of Saturn and his fourth satellite. He constructed object-glasses of the enormous focal length of 130 and 136 feet; and in order to use glasses of such dimensions without the encumbrance of tubes, he placed them in a short tube at the top of a long pole, so that the lens could be turned in any direction on a ball and socket joint, by means of a string, and be thus brought into line with another short tube containing the eye-glass, which he held in his hand. The magnifying power of such telescopes is found by dividing the focal length of the object-glass by the focal length of the eye-glass.

178. The earliest form of the telescope was different from this. The story of its first discovery is well known, and, if it is to be accredited, it would seem that one of the most important aids which science has obtained was put into her hands by a child. The children of Jansen, a spectacle-maker, at Middleburg, in Holland, it is said, amusing themselves, as children will do, with their father's tools during his absence, one of them got hold of a convex and a concave lens, and looking through both these at once, the concave one being next the eye, he was delighted to find he could read the hour on the dial of the old town clock. On their father's return they reported their discovery, and, to the father's credit, he did not let it slip. This occurred about the year 1590, and in the year 1609, by the use of such an instrument directed to the heavens, Galileo discovered the satellites of Jupiter

and settled the problem of the motion of the earth, and the whole philosophy of the planetary system.

179. This telescope, which is known by the name of Galileo's, from his successful application of it to astronomical discovery, is equally simple in its principles and construction as the one we have described in article 177, the difference between them consists in this, that in Galileo's telescope, instead of the convex eye-glass being placed *behind* the image to receive the *diverging* rays and render them parallel, a concave one is placed at a position nearer the object-glass, viz. *before* the image, so as to receive the *converging* rays and render them parallel.

180. This telescope presents the object in its erect position. It is the arrangement adopted still in field and opera-glasses, but the objection to its application for higher purposes is, that the eye-glass bends the parallel rays outwards, and therefore the eye requires to be placed very close behind the eye-glass in order that a sufficient number of rays may enter the pupil; and even at the best the field of view in this telescope is much narrowed.

181. It does not fall within our limits to explain refinements in the construction of optical instruments, nor to show how, by the exercise of ingenuity and patience, the defects arising from spherical and chromatic aberration, which Newton had considered insurmountable, have been overcome. The history of the improvement of achromatic object and eye-glasses, exhibits perhaps as pleasing an instance of the successful application of mathematical rule to practical purposes as we shall anywhere meet; and the triumph which has been recently achieved in bringing the achromatic microscope, whose object-glass consists of eight lenses, viz. two triplets and one doublet, to its present perfection, attests what may be done by man when his powers are devoted to a given object.

182. It was thought, and still is by many, that the principle discovered by Hall, and by means of which he overcame the

effects of chromatic aberration, by the combination of lenses of glass possessing different dispersive powers, was to be found operating in the human eye. It was supposed, that by the combination of the different humours which exist in the eye, that organ was rendered an achromatic instrument. How far this opinion is correct is not quite determined ; but it is certain, as we have shown in a previous chapter, that chromatic aberration is not entirely rectified in human vision.

CHAPTER XVI.

VISION (*Continued*).

THE APPENDAGES OF THE EYE.

183. HAVING described the eye as an optical instrument, we proceed briefly to describe its fitting-up or mounting; for it is well known how much the efficiency of an instrument depends on the facilities of using it. If many accessories are required for using an artificial machine, it may be readily supposed that many more will be found attached to a structure so delicate, so complex, and so perfect as the human eye. There will not only be the tackle for working it as an instrument, but there will be the provisions for the protecting, nourishing, cleaning, and repairing it, as a living, sensitive organ of the body. With the view of not being tedious, we shall give little more than an enumeration of such parts and appendages as are of primary use, and the object of which is well understood; premising that, much as the eye has been an object of study, there are many of its parts the special use of which is not yet ascertained.

184. The eye, then, is for safety seated deep in the bony cavity of the head formed by the union of seven bones of the cranium. These cavities are called the orbits or sockets of the eye. They are conical and slightly quadrangular in shape, and their outer margins next the temples are distinctly scolloped or hollowed, with a view of allowing the eye to traverse a wider range in looking outward. The upper margins of the sockets are, as artisans express it, *undercut*, so that the cavity of the orbits expand a little within, and the ball of the eye is thereby held more securely in its place, and protected from external injury.

185. These bony cavities, or orbits, are pierced in different places for the transmission of the necessary nerves and blood-vessels. One fissure is situated at the joining between the outer sides of the orbits, and is called the *spheno maxillary fissure;* through it passes a branch from the fifth pair of nerves. This nerve rises in the brain, and sends a branch to each of the organs of sense; and its office is very interesting, being not to receive the impressions peculiar to the different organs of sense, which might naturally enough be inferred from its invariable presence in them, but to supply these organs with general sensibility and nervous influence. Another fissure, called the *sphenoid fissure*, is betwixt the roof and inner sides of the orbits. It opens from the head, and transmits another branch of the fifth pair of nerves, which, passing along the roof of the orbit, comes out through a notch in its upper margin, and is distributed over the forehead and upper eyelid. Through the sphenoidal fissure are likewise transmitted the ophthalmic veins, and all other nerves, except the optic nerve.

186. A third opening, which is circular, called the *foramen opticum*, gives passage to the ophthalmic artery and optic nerve. Besides these perforations in the orbits, there is in the corner next the nose, and close to the margin, a deep groove leading into the lachrymal canal.

187. The origin of the optic nerves is not yet known. Fibres from the optic nerves are derived from the *corpora geniculata*, the *corpus quadrigeminum*, and the *optic thalami.* The optic nerve consists of a bundle of fibres of medullary matter, cased in minute transparent tubes, enclosed in a common sheath. The sheath is pierced half an inch from the ball of the eye by an artery called the central artery of the retina, which, accompanied by several small veins, reaches the centre of the nerve, and passes with it into the interior of the eyeball, not exactly in the axis of vision, but about a fifth part of an inch towards the nasal side. From the optic commissure backwards the optic nerves are more

soft and pulpy, and do not seem to possess any neurilemma. At the point of its entrance into the eyeball, the dimensions of the sheath are suddenly contracted, and it terminates in a fine *cul-de-sac*, pierced with minute holes or pores. Through these pores the nerve passes into the interior of the eyeball in divided portions, but immediately reuniting expands into a delicate cup-shaped membrane called the retina, which lines the whole back part of the eye, as formerly explained. It is upon this delicate membrane, as on the table of a camera obscura, that the image of external objects is thrown.

188. In order to enable us to bring the axes of the eyes into the line of the object to be inspected, the eyeballs are furnished with six muscles arising from the bony surfaces of the orbits, and inserted into suitable parts of the sclerotic. Four are called *recti*, that is, straight or direct muscles; the fifth and sixth are the oblique superior, and inferior, so called from the obliquity of their insertion and of their line of traction. The *recti* are flat, ribbon-like muscles, each about half an inch broad, which arise together at the back part of the orbits, round the *foramen opticum;* they end in broad, thin, glistening tendons, attached to the sclerotic at four equidistant points, about a quarter of an inch from the fore edge of the cornea, above, below, and on either side; hence they are designated the superior, inferior, internal, and external straight muscles. The effect of their action singly is to draw the front of the eye towards the side on which the muscle works, and thus either to elevate or depress it, or to direct it inwards or outwards. The combined action of any two adjacent muscles is to bring the axis of the eye into intermediate directions.

189. The arrangement of the *superior oblique*, or *trochlearis*, is worthy of attention. It is a round, tapering muscle, which arises at the back part of the orbit on the nasal side, and ends in a smooth, round tendon. As the office of this muscle is to produce an oblique motion of the eye, directing it downwards and outwards, traction backwards in the line of

its insertion would not suit; the direction of its action must therefore be altered, and this is done by the use of a pulley, which gives name to the muscle. The pulley through which the tendon of this muscle passes is a round loop of cartilage fixed to the roof of the orbit towards the nasal side, just within the margin; and the tendon, enveloped in a lubricated extensible sheath, after passing through the pulley, turns obliquely backwards and outwards, and spreading at the same time into a thin, fan-like expansion, crosses *over the ball of the eye*, and is inserted into the sclerotic at the external and back part of the ball.

190. The inferior oblique muscle arises broad within the lower edge of the orbit towards the nasal or inner side, and passing obliquely backwards, *under the ball of the eye*, is inserted in the sclerotic at the outer and back part opposite to the insertion of the *trochlearis*. It directs the axis of the eye upwards and outwards. By the single or combined action of these six muscles every desirable movement may be given to the eye.

191. To prevent injury to the eye, and to the nerves and blood-vessels contained within the orbits, arising from the working of the muscular tackle we have described, the whole vacant space in the orbits not occupied by the eyeball and its appendages is filled by a cushion of soft fat, contained in elastic membranous cells, which permits the free movement of the several parts, while at the same time it keeps them separate, and affords them as well as the eyeball itself a suitable and safe support.

192. A seventh muscle finds room within the narrow bounds of the orbicular cavity, namely, that appropriated to the raising of the upper eyelid, and hence called *levator palpebræ superioris*. It has its insertion at the back of the orbit, and passing along the roof of that cavity its tendon is inserted into the thin cartilaginous edge of the upper eyelid, which it serves to draw back.

193. The offices of the eyelids are multifarious. Thus, they

shut out the light during sleep, closing involuntarily when nature is exhausted ; they keep the surface of the eye moist, and clear it from adhering extraneous particles—this they do by washing over it the saline water formed in the lachrymal vessel; they also lubricate the surface with the unctuous matter formed in the glands which run along their inner margins. By their quick powers of motion in winking, which is also an involuntary action,[1] they intercept the entrance of insects or floating bodies. When drawn towards each other they limit the admission of excessive light. When dust or rain are drifting against the face the eyelids are drawn nearly close, but not so as to prevent vision ; and the eyelashes with with which their margins are fringed serve at once as eaves to carry off the rain, and as *chevaux-de-frise* to prevent the entrance of hard substances.

194. The eyelids are covered by an extremely soft and elastic skin, which rests on, but is very loosely connected with, the cellular tissue beneath. Beneath these, again, there runs round the margins of the lids, in elliptical folds, a broad layer of muscular fibres, called the *orbicularis*. These muscular fibres are attached by thin peculiar tendons to the temporal and nasal bones at either corner of the eye. Their office is to close the eyelids, and to do so with the utmost celerity, so as not to interrupt vision; and this their peculiar structure enables them to accomplish in an admirable manner. Their mode of action may be illustrated by taking hold of the opposite corners of a handkerchief or a bundle of cords, and drawing them suddenly out of their loose and curved position into the straight line. According to the laws of mechanics, this is just the movement to give celerity, though at the expense of power; but power or force is in the present instance of no importance, while speed is all in all. The string of the bow, while straightened to discharge the arrow, illustrates both the motion and the celerity of this mode of movement.

[1] See reflex nervous action explained in next chapter.

195. Around the inner margins of the upper and under eyelids, and shining through the thin membrane which lines them, are arranged numerous vertical rows of minute whitish glands, like grains, which secrete an unctuous matter which exudes through minute orifices along the margins of the lids, and, when mixed with the lachrymal moisture, serves to lubricate and keep bright the surface of this wonderful optical instrument.

196. There is only another appendage to describe, to wit, the lachrymal apparatus, for moistening the eye and washing from it any adhering particles. The lachrymal gland is a white, flattened, lobulated body, of the size of a small bean, lodged in a depression within the margin of the orbit, and covered externally by the orbicular muscle. The office of this gland is to secrete tears, a process which is probably constantly going on, though it is only when we are under the excitement of grief, or the stimulating effects of pungent odours, or of any substance which injures the eye, that its action is so increased as to cause the secretion to overflow. This lachrymal secretion is poured out upon the eye through seven small orifices arranged on the fore part of the upper eyelid. When called into action by the presence of any irritating cause, these emit their secretion, while the eyelids wash it over the surface of the eye, thereby carrying the offensive matter towards the inner corner, to a part called the lachrymal lake, which serves as a reservoir for the superabundant moisture, and from whence it is drained off into the nose by an appropriate duct.

197. At the entrance to this reservoir, above and below, there is a small prominence at the inner edge of each eyelid. If we take the trouble to examine the inner surface of these, which is easily done by turning them back with the finger, we will discover that they have small orifices, or punctures —*puncta lachrymalia*—to admit the excess of fluid contained in the lachrymal lake, and convey it by two converging canals to the lachrymal sac. The lachrymal sac is a mem-

branous bag about as large as a kidney-bean, lodged in a vertical groove in the lachrymal bone, and which, narrowing itself into the lachrymal canal, passes directly downwards into the chamber of the nose, which it enters on the outer side by a slit in the mucous lining.

198. The above is merely a hurried enumeration of some of the more prominent arrangements connected with the organ of vision. To extend our description further would require more time than we can spare. When we mention that in the description of the mere fitting up, apart altogether from the construction of the instrument itself, we have enumerated at least thirty distinct organs and contrivances, the reader will have some impression of the wonderful amount of care that has been bestowed upon this important organ.

199. Whether we consider the provisions which are made for its nourishment, growth, and preservation as a living organ of the body, or examine its structure as an optical instrument; or whether we direct our attention to those contrivances and adaptations which are clustered round it, and which have special reference to its convenient working as a nice and delicate machine; or, taking into account the wonderful compactness of the organ, occupying as it does with all its appendages, little more than an inch in diameter, we reflect on the wonderful nature of its office, throwing open to us the illimitable fields of space, and bringing before us with mathematical fidelity the forms of external nature, presenting them in all their truthfulness, and in all their beauty, —in every light in which we may regard it,—we can feel no hesitation in assigning to the eye the highest place among the organs of sense.

CHAPTER XVII.

VISION (*Continued*).

HEAT AND LIGHT—THE ETHEREAL MEDIUM—THE DIFFUSION AND TRANSMISSION OF POWER.

In chapters xi., xii., and xiii. we have treated of radiation and refraction, and of the corpuscular and undulatory theories of light; and in chapters xiv. and xvi. we have described the human eye and its appendages. It now falls to us to introduce the subject of vision; but before we can do so, it is necessary that we direct the reader's attention to the nature of that medium, or atmosphere, through whose special agency we have the benefits at once of light and heat and vision. It is well that we should realise the constitution of this, at once the mightiest and the most neglected of all the powers of nature.

In chapter vii. we have given the reader a conception of the atmosphere of our planet as an elastic medium, and of the nature of those tremors, or vibrations, produced in it by the sharp and rapid mechanical impulses inflicted by the vibrations of stretched cords in stringed instruments; by stretched membranes, as in the drum; and by compressed air thrown into tubes, as in wind instruments. All this will materially help us to understand the nature of that infinitely vaster and more powerful elastic body called the ethereal medium, and the nature of those never-ceasing vibrations of which it is the subject, and which, as we shall see, besides being the media of light and heat and vision, are indispensable both to animal and vegetable life.

It is, indeed, a singular circumstance, that there should

exist all around us a physical agent which discharges the most important offices in creation, but which is nevertheless very lightly esteemed, and very little studied by those whose existence depends on it. The bulk even of educated men smile when it is alluded to, as if it had merely a mythical or imaginary existence, or as if its being, or its not being, were to them a matter of supreme indifference. In his present remarks on this wonderful power, the author will follow the description he has given in a recent work entitled, "The World Dynamical," etc., merely altering or amplifying where necessary for the sake of clearness.

The medium of which we speak pervades all space, it penetrates all substance, it stretches as far as the remotest stars and nebulæ; and yet we neither see it, hear it, nor feel it objectively. From this circumstance the unlearned think it must be a something of the most subtle and impalpable character, as indeed its name implies; instead of this we have evidence that it is the most tremendous power which exists in nature, and the fittest emblem of Divine power from its ubiquity, and the vastness and variety of its operations. It may, indeed, not irreverently, be called the right hand of Deity, for He stretches it throughout all space, and every where it works His Will.

Its pressure must almost exceed the bounds of human belief. A calculation may assist the mind to form some conception of its amount. The velocity of the propagation of vibrations in any elastic medium depends on the relation between the elasticity or tension of the medium, and the inertia or weight of it molecules. The greater the pressure or tension of the medium, and the lighter the molecules composing it, the greater is the velocity of the vibrations transmitted through it. The velocity of sound, for instance, through the air is about 1125 feet a second: the velocity of light has been calculated at 186,000 miles in the same brief period; let us say, for simplicity, 200,000 miles. Now, we possess no means of ascertaining the fact, but it is probable

that the molecules of the medium of which we speak are inconceivably light and minute. If we assume them to be of the same weight as the molecules of our atmosphere, the pressure of the medium will be 960,000 times greater than that of our atmosphere. Let us suppose, however, that they are only one-hundredth part the weight of a molecule of air: on this supposition the pressure of the ether will be 9,600 times that of our atmosphere, which, let it be remembered, bears with a force of about fifteen pounds on every inch of the surface of the earth, and of our bodies. As the ethereal atmosphere, however, penetrates all substances, it does not affect them as a weight or pressure; it is only by its movements or vibrations that we have any consciousness of its existence, as it is only by these that it disturbs or in any way affects physical bodies. And how powerfully these movements occasionally act we have proof in the destructive energy displayed by fire, which is the violent vibratory action of this ethereal medium.

As this subtle though powerful medium penetrates all bodies, even the densest, it is thus, as it were, the cushion on which the ultimate atoms of all things rest. It surrounds every atom and keeps each one apart from its fellows, and by its movements, which never cease, it maintains them in constant though invisible vibration: the mountains, the solid earth, and everything on its surface is thus alive with a molecular movement which knows no pause. If it is not, as many hold, the agent which prevents our atmosphere from condensing into a solid or a liquid form, it is, beyond doubt, the agent whose constant motion preserves uniformity in the quality of the air we breathe, by a constant mixing of its ingredients in the way explained in a previous chapter, and by a dissolution and dispersion of its noxious vapours.

But though the absolute pressure of this medium is so tremendous, yet mark how nature's agents work for nature's ends. This vast ethereal ocean which, when lashed into violent action—as is the case, in the highest degree, in the sun, and as

is the case, in a greatly modified degree, on the surface of the earth under the commotion which we call combustion—has power to dissipate the most obdurate materials—metals, rocks, and cities yielding before it, and becoming reduced to ashes or resolved into their original elements; this same medium, when its surging movements reach our earth from the sun, weakened by a radiation expanded over so wide an area, may be likened to the calm ocean which, with musical ripple, plays idly with the sands of the beach, and with the straws and other light bodies which float on its surface; so perfect is its elasticity, so fine its touch, it appears as if it were mastered even by the weakest and most trifling objects; it is entangled by nets and cobwebs; in furs and flannels and feathers its tremors are arrested and reflected and re-reflected from fibre to fibre, so that with difficulty do they extricate themselves.

In its gentler cosmical movements it causes the vapours to ascend from the earth's surface, and the rivers to flow; with a delicate hand it also enables the animal and vegetable creation to build up their tender organisms. And though it does not guide their materials to their places, it helps forward the mechanical work; it keeps every atom in motion, and apart, so that the one may pass the other as, under the directing influence inherent in the living organism, they hurry forward to be built, each into its place, in the individual plant or animal. Without it, motion of any kind were impossible, and the earth, organic and inorganic, would be sealed in the grasp of eternal stillness, darkness, and death.

What is the agent which originates this all-important motion in the ethereal ocean? It is the sun—he is the great centre of mechanical motion and power. This mighty orb holds the planets in their places with an attractive power which only astronomers can calculate, and while he holds them, he bathes them with a constant stream of ethereal vibration. It is by means of these vibrations, which deal, as we have shown, not with bodies in the mass, but with the

atoms of which every physical body consists, that the sun is constituted the great originator and dispenser of power and motion on the earth's surface.

If it be so, if the sun is constantly streaming off energy which is essential to animal and vegetable life, whence is this energy derived? how is it maintained? and how is it transmitted to us? It is most instructive in a philosophical point of view to note how the Great Architect has, in a physical world, subjected all His workings to law, and how numerous and diverse results are accomplished by a machinery at once simple and efficient. The law of parsimony cannot fail to press itself upon the attention of every observant student of nature—that principle to which we have more than once alluded, by which one and the same agent is endowed with the power of discharging many, and often the most dissimilar offices; this we cannot fail to observe in the case of the great cosmical machinery with which our attention is presently engaged.

All motion is produced by the application of force in one form or another; and this very peculiar vibratory motion of which we speak is now by most men of science believed to originate, not from combustion or chemical combination, but from the application of mechanical force. The prevailing theory is, that the sun, by virtue of the mighty attractive power with which he is endowed, is drawing constantly towards his surface asteroids and other large bodies from space. The effect of such masses impinging upon a body such as the sun—whose molecules, even more than those of other physical substances, are not in contact, but held apart by the violent action of this all-penetrating ether—must necessarily be to produce an increased vibratory movement in the entire molecules of that vast orb commensurate with the force of the stroke. This momentum, or force, of the impinging mass is thus at once transmuted into the intense vibratory movement of the many billions of molecules of which the sun consists, and the motion and the force are

from them given off gradually and continually to the molecules of the surrounding ethereal atmosphere, and by it this same energy and motion, probably somewhat on the same principle as sound, are transmitted with inconceivable speed to the earth, and to all the planets which surround the central orb and form the members of his system.

These vibratory movements, which vary thus in strength or intensity, differ also, like the vibrations of sound, in quality and pitch. Till we have a better theory, we may suppose that the larger and heavier molecules of the ethereal atmosphere perform a slower oscillation, and produce that more disturbing action on physical bodies which we call heat, and that a considerably smaller class of ethereal molecules, in conformity with the known laws which govern the vibrations of elastic media, perform those smaller and more rapid, but less disturbing oscillations which, received on the optic nerve, excite in us the sensations of light and colour. On this theory each primary colour will have its own size and weight of molecule and its own size and rapidity of vibration.

Heat and light are thus to be viewed as the great bass and treble notes of the same ethereal instrument, or we may call them twin brother and sister. Heat does all the heavy work, and light possesses all the beauty and the grace—and how useful is she besides!

Though these vibrations proceed directly from the sun as their principal source, they are also produced, as we well know, by the violent action which accompanies chemical combinations, and which we call combustion: such especially as the combination of oxygen with hydrogen and with carbon.

It is chiefly after the vibrations have been received on or into the substance of terrestrial bodies, and then, in whole or in part, radiated or reflected from them, that we enjoy them as the media of vision. These vibrations are reflected from polished surfaces; they pass through transparent bodies; they penetrate a short way among the outer molecules of white bodies, and are then radiated from their substance; or they

are reflected from the invisibly minute facets which compose certain white bodies, without the loss of any of the elementary vibrations which constitute pure light. Other substances have the power or property of receiving the vibrations into their substance, and retaining them there, their molecules receiving from them that motion which we call heat; such bodies appear to us black. Other bodies receive and retain or utilize in this way only certain of the vibrations, while they radiate others, and their colour depends on the peculiar vibrations which are so radiated, and which enter the eyes. This we explained in chapter xi.

These various vibrations, streaming from every point of terrestrial bodies, and concentrated on corresponding points of the retina, in the way explained in earlier chapters of this volume, give us a cognition of the form of external objects; and the peculiar colours by which we are affected, not only enable us better to distinguish one object from another, but serve as most useful indexes by which to recognise the latent qualities of different substances. Another highly important object it accomplishes—it gratifies us with that sense of variety and beauty which colour so largely imparts to our æsthetic nature.

Only so far can we here enter upon the nature of vision. The reflections which we have to make upon it as a mental state we defer till we come to consider it in connection with the subject of perception. The reader will, however, scarcely fail here to observe that what is within the mind is sight—what is without is motion.

PART III.

THE SPECIAL SENSES AND GENERAL SENSIBILITY.

CHAPTER XVIII.

THEORY OF VISION.

DIFFICULTIES CONNECTED WITH THE THEORY OF VISION—SINGLE AND DOUBLE VISION AND THE DOCTRINE OF THE CORRESPONDING POINTS OF THE RETINÆ EXPLAINED—THE USE OF TWO EYES.

VISION is beyond all question the most wonderful of our senses; and the exercise of it affords us the greatest amount of pleasure and instruction. The author will in the present chapter restrict himself to the consideration of certain difficulties which have for more than a hundred years exercised the ingenuity of optical writers, and which seem never to have received any explanation to satisfy either men of science or mental philosophers.

The author in this chapter will offer an anatomical explanation, which affords a simple solution of the class of difficulties to which he refers. His explanation possesses the advantage of throwing additional light on the general subject of perception, he therefore hopes it may receive the consideration of students, both of physiological and mental science.

The theory of vision has been the subject of much more scientific study than that of any of our other senses, but notwithstanding this, the subject is still incumbered with difficulties and contradictions, the solution of which is essential to our possessing an exhaustive theory. Some of these difficulties appear to the writer to be closely connected, the one with the other. Such are the questions:

1st. Regarding single and double vision, as dependent

on the excitement of what are usually styled the identical and the non-identical points of the retinæ of the two eyes, but which we shall here call, more correctly, the *corresponding and non-corresponding points* of the retinæ. Why does excitement of the corresponding points produce single vision, and excitement of points which do not correspond double vision?

2nd. The image of objects is inverted on the retinæ. How does it happen that we see objects in their true, upright postures?

3rd. Does our perception of objects and of colour occur on the retina, or in the cerebral lobes from which the optic nerves have their origin?

4th. Objects are said to be seen in a direction at right angles to the part of the retina which is impressed with their image. How far is this true? What is the nature of our conception of visual direction? Is it intuitional and absolute, or is it acquired by experience, as a simple and necessary result of this and the physical laws of light? or, lastly, does it arise from some inscrutable law of the mind, or of the retina?

Now, in spite of all that Dr. Reid and Mr. Stewart have said of the absolute futility of explaining the philosophy of the senses by means of physical or anatomical investigations and theories, we venture to say that had anatomists been able to trace the course of the optic fibres from their source in the different lobes at the base of the brain, to their termination in the retinæ, they would long ere this have simplified the theory of vision, and greatly assisted our writers on mental philosophy; but the nervous and cephalic structures are so delicate and minute, that hitherto physiologists and anatomists have not successfully accomplished this task. Until, then, their inquiries have settled the anatomical question, all that we can do is carefully to observe the phenomena of vision, as they are presented under ordinary and under unusual circumstances, and from these to frame a theory by which they may be

rationally explained; and this we shall now endeavour to do with reference to the subject of single and double vision, as depending on the excitement of the corresponding and non-corresponding points of the retinæ.

When an object is exposed to light, an image of the external object is formed on the retina of each eye. It is through the peculiar impulse thus cast upon the retinæ and optic nerves that we are affected with the phenomenon of vision. Here then emerges our *first question*, and a very important one. If there are impressions made on each retina, how is it that in ordinary vision we seem to have but one sensation, and the perception of but one object? When we touch an object with both hands we have two sensations; it has been generally supposed that it is not so in vision, but that we are conscious of the mental representation of one object only.

To get over the difficulty, some writers have alleged that in looking at an object we use only one eye at a time, as is the case with fishes whose eyes are set on different sides of the head, and as is the case with parrots and some other birds and beasts, which either cannot at all, or can with difficulty, direct the axes of both eyes simultaneously to an object.

Other writers have hinted in a general way at the decussation of the optic nerves as explaining the difficulty, as if there were a sort of fusion of the two impressions into one at the point where the optic nerves meet. This unscientific explanation will not stand criticism. It is evident that even if impressions such as those implied in vision could possibly be fused into one, yet, as the nerves again separate before forming their connection with the brain, these impressions must, by this separation, necessarily become again divided and presented to the mind double.

Before attempting an explanation of the nature and cause of what is called single vision, we must premise by saying that a considerable amount of misunderstanding of the subject has been exhibited, though since the discovery of the stereo-

scope the facts of the case have become much more generally understood than formerly.

The truth is, in ordinary vision there is no such thing as single vision. In one sense, indeed, our vision may be said to be single, but in another and a stricter sense it is *double.* A little attention will show us how the case stands. Take two shillings of like appearance, and place them with the corresponding sides up in the different compartments of the stereoscope, but so far apart that they do not appear to coalesce. In this position they are distinctly seen simultaneously by each eye as separate objects. Cause them next gradually to approach till they seem to coalesce into one. We say *seem* to coalesce, for there is no proper visual coalescence. Even when they seem to coalesce, there are still two impressions made, one on each retina, and a corresponding impulse is from each of these membranes sent to the brain and to the mind, though from the close resemblance of the two impressions we have great difficulty in distinguishing the one from the other.

To prove that such is the case, let us reverse one of the coins in the stereoscope, and note the effect. When different sides of the coins are simultaneously presented we have no longer the impression of one coin, but of two coins occupying the same place; both are visible, and they appear as if the one were seen through the other. This presentation is so anomalous that the eye and the judgment become alike puzzled by it, and there arises an evident effort to reduce the phenomena to a normal and intelligible object of vision. A succession of transformations is the consequence of this joint action of the mind and of the disturbed nervous centres; at one moment we see one coin, and then suddenly it disappears, and the other takes its place; then we see both coins at once, as if one through the other; or a part of each may become alone visible.

In ordinary vision, then, we must conclude that an object makes an equal impression on the corresponding parts of

each retina, and therefore, in ordinary vision, as there are two images on the retinæ, so there are really two sensations, or mental impressions, though we are intellectually unconscious of the fact of duality, and unable to distinguish the one from the other. The stereoscope, however, as in the experiment with the coins, enables us to make separate and distinguishable impressions on the corresponding points of each retina, and thus to prove beyond a doubt that each eye acts apart and affects the mind by a separate impulse.

The phenomenon of what has thus commonly, but not with strict propriety, been called single vision having been explained, the question remains: If there are really two retinal impressions, how do we account for the images, or mental impressions they make, appearing as if superimposed the one on the top of the other? The eyes are set apart in the head, and the supposed sensory ganglia at the base of the brain are all in duplicate, and the cerebral hemispheres divide the head in two equal sections. How then are we to account for the visual images being united? Different ganglia, or lobes, have been suggested as the probable sensory organs in vision. Fibres from the optic nerves are traced to the *corpora geniculata*, the *corpora quadrigemina*, and the *optic thalami*, and it is thought, also, to the *crus cerebri*, and each of these have been selected as the probable sensory by different authors; and as the retinæ as well as these lobes exist in duplicate, and as they also, except the *corpus quadrigeminum* and the *crus cerebri*, are situated on the different sides of the brain, it has been generally assumed that *the mind* combines the two impressions, as it were, into one. This was, and we suppose still is, the opinion of Messrs. Wheatstone and Carpenter, and it was for many years the writer's opinion; but the phenomena about to be mentioned convinced him that he was wrong, and that there exists *a physical cause* for the union of the two images or impressions. The experiments he employed were very simple, but they are quite sufficient to afford a complete explanation at once

of the nature and cause of the phenomena connected with the corresponding points of the retinæ, and of our seeing objects, if not single, yet as if overlying each other.

When we take two strips of white cardboard, say an inch broad, and insert one at each side of the stereoscope, we find that each strip is distinctly seen by each of the eyes, to which it is presented, but when we make the strips gradually approach, till the two ends appear, when seen in the stereoscope, to overlap, say an inch or more, the effect produced is worthy of consideration. Where the strips seem overlapping, their brightness is observed immediately to become very much increased, so much so, indeed, that when we fix the attention on the rectangular part formed by the overlapping ends, all the rest of the strips by-and-by *become invisible*, and the overlapping parts alone remain distinct objects of vision. We may here, however, by the way mention, that either of the cards may be recalled to sight by the simple act of moving it two or three times backwards and forwards, and thus exciting the retina and attracting the attention; the superior brightness, however, of the overlapping parts remains always unimpaired.

Such then are the facts, but what is the cause of the superior brightness where the cards appear to overlap? And what is the cause of the apparent overlapping where corresponding points of the retinæ are excited? We are not aware of any writer having distinctly laid before us a specific physical cause accounting for the several phenomena we have been speaking of, and yet it appears to us that they very clearly point to an anatomical cause.

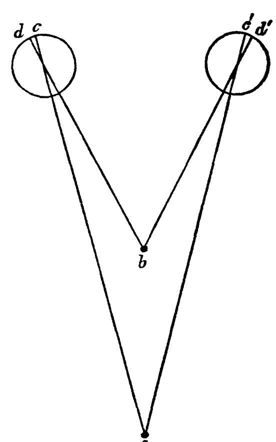
For the sake of those who may not be conversant with the subject of the corresponding, or, as they have been generally called, identical points, we may explain.

In the centre of the retina is a minute pit, or depression, called the *punctum luteum*, or *fovea centralis*, this part is peculiar in its anatomical structure, and it is the part which possesses the greatest sensibility. While there is throughout

the whole retina a certain sensibility to light and colour, this central point is the only part which possesses a high discriminating power. The reader may convince himself of this fact by holding a book before him at his usual reading distance, and fixing his eyes upon the middle letter of a word of five or six letters: he will find that, while examining this one letter minutely, in its form and its parts, he will be unable to tell the forms of the extreme letters of the word. It is not altogether easy to make the experiment, for the eyes have an involuntary searching motion, which can only be repressed by practice, and a determined concentration of the attention upon the minute object examined.

When we fix our eyes upon any one object in an extended landscape, we naturally direct the axes of the eyes to that object, and when this is done, an image of the object examined falls on this central point of each retina, and all the details of the landscape lie mapped around on the *corresponding points* of the two retinæ, and appear single. If we were now, however, to squint, immediately the whole landscape, with all its details, would appear double.

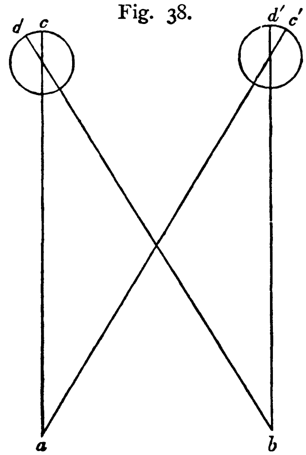
Fig. 37.



To take another example. Let us direct our eyes to a lighted candle *a*, 12 or 15 feet from us; it appears single, because the images *c c* fall on the central points, which are the *principal corresponding points* of the retinæ; if now we hold up the finger at *b*, while we continue to look at the candle, the finger will appear double, because the images *d d* fall the one to the *right* and the other to the *left* of the central points of the eyes. When, however, we direct the *axes* to the *finger b*, immediately the *candle* becomes double, and from the same cause.

If we place a second candle *b* a short distance from the first one *a*, then, when we examine the one candle, the other candle, which is at the same distance from us, will appear also single, because both the images *d d* fall on the same side of the central points of the eyes, and therefore affect *corresponding points of the retinæ.*

Fig. 38.



It will thus be seen that the corresponding points of the two eyes are points equi-distant from the central points; and if we call the central points polar points, then the corresponding points in each eye are points which have the same latitude and longitude on each visual orb, or correspond geographically in position.

Before attempting an explanation of these singular facts, let us briefly state the opinions which have been promulgated by some of the most eminent writers regarding the phenomena.

Dr. Porterfield, in his work on the "Eye and Vision," practically denies the existence of corresponding points, and explains single vision as the consequence of an immutable law which enables us to judge of the direction and distance of objects, and thus to declare the two impressions to have reference to one object. He explains the double vision which occurs when non-corresponding points of the retinæ are excited, to be the result of a false judgment on the direction and distance of bodies.

Dr. Reid, in his "Inquiry into the Human Mind," devotes thirteen chapters chiefly to the subject. He states that it has occupied his thoughts for thirty years, and he accepts it as a mystery which cannot be explained. In alluding to Newton's hypothesis—of which more anon—while Reid com-

mends the philosophical humility of this great man, he at the same time declares his suggestion to be of much the same value as the hypothesis of the *Indian philosopher's elephant*, whose back was supposed to sustain the world.

Sir Wm. Hamilton attempts no explanation, neither does Sir David Brewster in his famous controversy with Professor Wheatstone, on the law of the identical points, and visual direction.

Dr. Smith, in his "Optics," attributes single vision *to custom* or habit; and Professor Wheatstone and a great many other writers seem also to attribute it, as we have said, to this cause.

Dr. Carpenter takes this view. In his Physiology (p 705) he says: " One condition of single vision seems to be that the two images of the object should fall on parts of the retinæ accustomed to act in concert, and habit appears to be the chief means by which this conformity is produced."

Buffon thinks we first see objects double and inverted, and that we correct this judgment by experience. Blanville, Gassendus, Porta, Tacquet, and Gall maintain that we see with only one eye at a time.

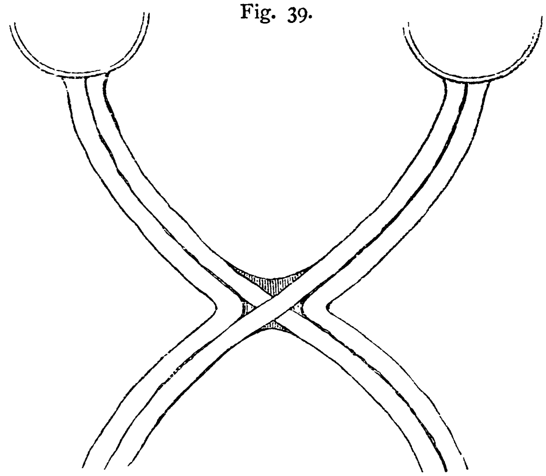
Perhaps we may say that the majority of writers have looked no deeper than the surface of the retina, and have been content to state the phenomena of the corresponding points, and single vision, as depending on an inscrutable property of that membrane; and perhaps this is not so much to be wondered at, seeing that those corresponding points are distributed over the retinæ geographically, and not in parts which correspond anatomically. It is, however, much more curious that so many optical writers should be found attributing our sense of visible direction also to a like inscrutable property of the retina.

Some anatomists, as we have said, from seeing the decussation of the optic nerves, have supposed that this might explain single vision. Dr. Wollaston, from a peculiar occasional disordered state of his vision (Phil. Trans., 1824), suggested that there is a crossing of the fibres from the

inner parts of the retinæ of both eyes to the optic thalami on the opposite side of the head, while the fibres on the *outer sides* of each eye go to the same ganglion on their own side of the head. Mr. Mayo and M. Solly also support this opinion.

To us this arrangement of the fibres is, to say the least of it, highly improbable. It implies, as will be seen by the diagram, that the retinæ are optically divided in two halves, the images, therefore, of objects falling on the centres of the

Fig. 39.



retinæ must be similarly divided, and one half of every object will be represented on the right side of the head, and the other half on the left side; while objects seen obliquely, and whose images fall on one side of the retinæ, will be represented only at the lobes on their own sides of the head. This is surely extremely improbable.

As anatomists have been unable to trace the course of the optic fibres from the *retinæ* to their ultimate termination in the brain, and opinion is nearly equally divided as to whether the true optic fibres cross at all at the commissure, or whether they cross in whole or in part, the writer, in the absence of proof, holds that there is no *separation* of the *true optic or visual fibres* from *each eye*, but that they go entire, each by its own course, to a common sensorium.

The phenomena observed in vision suggest an arrangement of the fibres, which affords a ready explanation at once of the long-vexed puzzle of the *corresponding points of the retinæ*, and also of the increased brightness obtained by the use of two eyes. In the diagram we have—in deference to what is probably the prevalent opinion—represented the optic nerve and optic fibres as crossing at the commissure.[1]

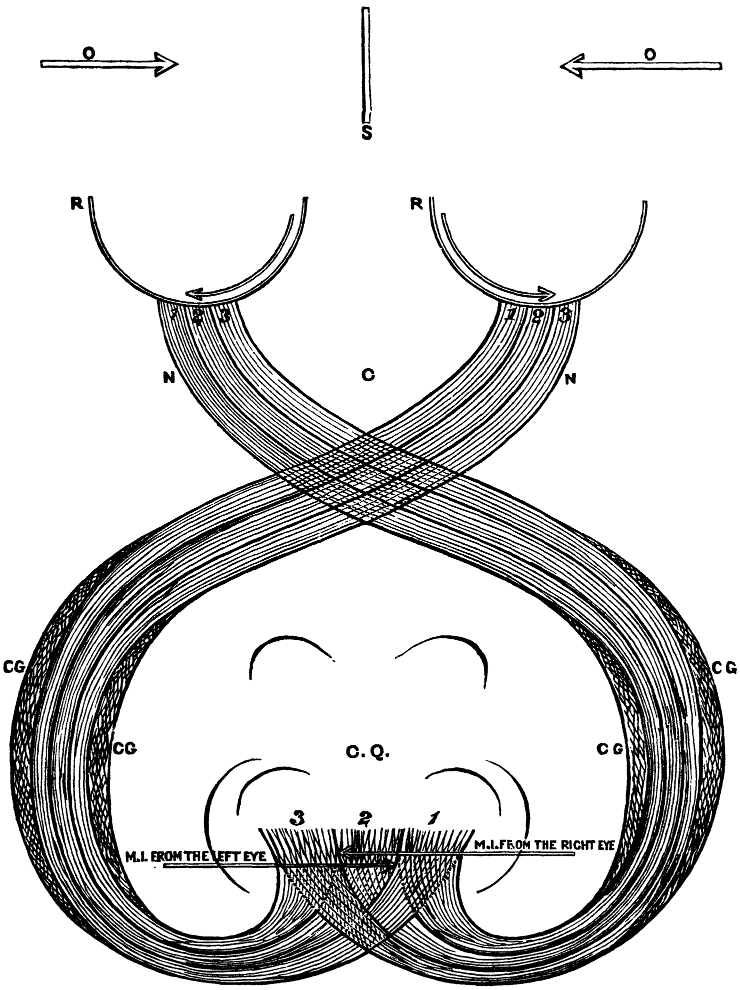
In the diagram (Fig. 40) R R represent the retinæ, the central points being in the centre of 2 on each retina, and N N represent the course of the optic nerves to the commissure C, where they cross; C G, C G are the positions of the *corpora geniculata* which seem to embrace the optic tracts (or nerves) as these turn inward towards the *corpora quadrigemina*, C Q. As this latter body has been proved to correspond with the optic lobes of fishes and birds, and as it is most intimately connected with the fibres of the optic nerves, and is moreover an important central ganglion, we at present assume it as the sensorium in vision.

The retinæ, for the purpose of explanation, we divide into three portions, 1 2 3 on the left eye, and 1 2 3 on the right eye; these corresponding numbers indicate *corresponding portions* of the retinæ, and for explanation we have marked the entire course of the optic nerves from these parts till they enter the sensory lobe. The corresponding nerves from 1 1 thus enter the portion of the sensory 1, those from the retinæ 2 2 enter the portion 2 of the sensory, and 3 3 enter at 3 of the sensory.

The corresponding points of the retinæ are thus represented by fibres brought into juxtaposition in the sensory lobe. O O are the objects, and represent the strips of cardboard which we have alluded to in the experiment with the stereoscope; and to show the direction in which they advance on the retinæ, we have represented them arrow-shaped. The strips when inserted in each side of the stereoscope first appear

[1] For the purpose of more easy explanation, the connection of the optic fibres with the retinæ is represented diagramatically, and not anatomically.

Fig. 40.



O O. Objects.

S. Septum of the stereoscope.

R R. Retinæ.

1 2 3, 1 2 3. Corresponding points on retinæ, and in the sensorium.

M I. Mental images overlapping in portion 2 of the sensorium.

C G. Corpora geniculata.

C Q. Corpus quadrigeminum.

C. Commissure of the optic nerves.

on No. 3 of the left eye and No. 1 of the right eye, and inverted; these are not *corresponding points*, and they affect the fibres 3 and 1 in the sensory, and therefore appear there as *two separate objects*. When we advance the strips, the images also advance to 2 2 on the retinæ; these are corresponding points, that is, they contain fibres which are locally connected in the sensory, and the impulses made on these parts of the retinæ are accordingly transmitted to No. 2 of the sensory, and we have the mental sensation of single vision and of the overlapping of these two parts of the cardboard. An examination of the diagram and a little reflection will convince any one, that in every instance in which the image of an object affects *non-corresponding* parts of the retinæ, the impulse will affect different portions of the sensorium, and the object will consequently appear double; while if the images of an external object fall on corresponding points of the two retinæ, the same portion of the sensory must receive the two impulses, and the object will appear single, because the two retinal images are there superimposed. This fact at the same time affords a very simple explanation of the circumstance of the increased brightness experienced when both eyes are employed, namely, that *the same portions of the sensorium then receive impulses from both eyes*.

In the diagram we have drawn two lines, M I, M I, in order to represent the positions of the mental images. These lines it will be observed are represented as overlapping in the sensory in No. 2. This explains to us how there is single vision of these portions of the object, and at the same time a double impulse on that part, and consequently greater brightness.

Were we to advance the strips still further in the stereoscope, their images would cover 1, 2, and 3 of the two retinæ, and the whole corresponding parts of the sensory here represented would be affected with single vision and increased brightness from the double impulses.

Without using the stereoscope we may have proof that

the use of two eyes gives us the advantage of increased brightness. Though this fact has been long known, yet the writer became first aware of it one day in church. Looking at a large white window curtain while his left eye was partially shaded by the left hand, he observed that the right half of the curtain was of a bright white colour, while the left half was of a gray colour; and why was this? Evidently because the portion No. 3 of the retinæ of the left eye received no light from the left side of the curtain, and the portion No. 3 of the sensorium therefore only received the impulse from No. 3 of the right eye, while the other portions of the sensorium, Nos. 1 and 2, received impulses from both eyes.

Now with reference to the experiments with the strips of cardboard, and with the window curtain, it will be admitted to be a well-recognised law or principle, that no objects having a given intensity of brightness can have that intensity increased by a mere *apparent superposition*. Two objects with an intensity 5 of white or coloured light can never by any mere mental or *apparent superposition* acquire an intensity 10. It requires a real physical union of the light from the two objects to affect us with the sensation of increased intensity, and that this physical union of the two impulses, in the common sensory, is effected in the way indicated we cannot doubt, especially as by this arrangement the doctrine of the corresponding points is also satisfactorily explained.

Let us now bring under the reader's notice a modification of the experiment with the stereoscope. The most noteworthy facts elicited when we employ a red and a blue strip, or a blue and yellow one, are that, while the brightness of the parts, which in the stereoscope appear to overlap, is increased, there is no blending of the colours so as to affect us with the sensation of purple or green; on the contrary, we see, as in the case of the reversed coins, one colour shining through the other; and then one colour disappears and the other

remains, then the first reappears and the second vanishes, and sometimes half of each appears at one time; or, it may be, small points of one colour seem to shine through the ground-colour of the other. This singular fact establishes a very interesting physiological law, viz. that though the combination of different vibratory impulses, external to the organism, produces the effect of an intermediate impulse or colour, yet the impulse of a different vibratory action on separate retinæ cannot be combined by the mind, but each impulse is reported pure and separate to the mind, though from the cumulative effect of the increased amount of impulse from the two eyes, and the consequent increased action of the sensory organ, the brightness is increased, or, in other words, the mind is more powerfully acted on.

To conclude a chapter already too long: the arrangement of the visual nerves which the writer suggests and represents in the diagram solves several difficult questions, thus—

1st. It explains the nature and cause of the phenomenon connected with the corresponding retinal points, and exhibits a physical cause for single and double vision.

2nd. It explains the cause of increased brightness when we use two eyes, whether in ordinary vision or in using the stereoscope.

3rd. The increased brightness, and other phenomena alluded to, also establish the fact that visual sensation is not in the retina, but in a common cerebral sensorium where the two impulses are united.

4th. These results possess also an important philosophical interest. The experiments of Helmholtz and others (to be referred to in a subsequent chapter), on the velocity of the transmission of sensation through the nerves, establish beyond a doubt that the sensations of touch are not experienced in the external parts of the body, but in the brain. The phenomena referred to in this chapter prove that visual sensations are likewise not in the retinæ, but in the brain. This affords to mental philosophers a solution of one of their

greatest difficulties. It has long been with them a question how the conception of extension and form enters the mind. Reid, Stewart, and Hamilton, as we shall afterwards see, concur in testifying that it is impossible to solve this problem; and the two former of these authors view perception, not only as a mystery, but as a miracle. Now we maintain that the phenomena here explained enable us at once to declare that the forms, movements, and positions of external objects are, by the means of nerve impulses, presented with geometric precision to the mind in the brain, and that we are thus made directly conscious of these primary properties of external objects.

In the next chapter we shall see that this theory simplifies the explanation which may be given of our knowledge of visual direction.

CHAPTER XIX.

THEORY OF VISION (*Continued*).

VISUAL DIRECTION—INVERTED RETINAL IMAGE AND ERECT VISION—MISCONCEPTION AS TO VISUAL DIRECTION.

HAVING in the preceding chapter explained the cause of single vision, namely, that it arises from the union in one common sensorium of the impressions from the two eyes, we shall find it an easy matter to answer the remaining questions, viz.: How we acquire a knowledge of visual direction? and how objects appear to us erect, seeing that the image on the retina is inverted?

It is not necessary to avail ourselves of the theory of a cerebral sensorium to answer these questions. This theory, nevertheless, at once removes all difficulty, and strengthens the arguments employed by Berkeley and Smith, which found our visual knowledge on experience.

The two questions of which we now treat have given rise to volumes of controversy. We shall, therefore, before attempting any explanation, in the briefest possible manner allude to some of the opinions which have been held regarding them, as these may be gathered from Dr. Reid's "Inquiry into the Human Mind," and the notes of his eminent commentator, Sir Wm. Hamilton, and from other more recent sources.

Kepler, the astronomer, first discovered that an inverted image of outward objects was impressed on the retina, and both he and Descartes explained our seeing objects erect by the circumstance that the rays from the different points of an object cross each other within the eye before reaching

the retina, and that therefore we conclude that the impulse which we feel on the lower part of the retina comes from above, and the impulse we feel on the upper part comes from below. To this explanation Reid very justly remarks, that the generality of men are not even aware of the fact that the rays cross and that the image is inverted, and therefore the fact can afford them no explanation of the phenomenon of erect vision.

Bishop Berkeley also rejected Kepler and Descartes' solution, and wisely, as we think, declared our knowledge of the direction or position of outward objects to be a judgment founded on experience, acquired by touch. In this he was followed by Dr. Smith, in his "Optics." Dr. Reid objects to this solution of Berkeley and Smith, and gives his reasons for holding that our perceptions of posture and direction, are not to be explained in any way patent to human intelligence, but must be accepted by us as a law of nature, or a law of our constitution. This constant habit of insisting that there is no possibility of throwing any light upon the laws of perception, was rooted in the mind of Reid and his successors almost as a religious tenet. His doctrine is, that the laws of the physical and moral world are established by the Creator, and that it is equally vain and childish to seek for an explanation of any of nature's primary phenomena. This is a prominent foundation-stone of Scottish philosophy, and a true and solid foundation it no doubt is; but then much more care and patience are to be employed in tracing nature's complex arrangements before we are justified in saying we have reached this primary, or *foundation rock*, on which philosophy and nature rest. It is the glory of Scotland that it took the lead of Kant and the German school in claiming for the mind, no less than for the physical world, the possession of fixed and established laws. Reid held by this as being the clue to all truth and the palladium of all sound philosophy, which it certainly is, but the doctrine must not supersede the exercise of our

eyes and intelligence on the works of nature: we must not be indolently satisfied to rest on one foundation principle. We fear this has been an error of our mental philosophers; and that from Reid's time until now it has materially impeded progress. How easy is it, when difficulties arise, to refuse to examine them on the ground that they pertain to the fundamental phenomena of nature, and are consequently inexplicable. Had Hamilton, whose mind was so naturally prone to enshrine the maxims of the great men of past ages, employed one half the strength with which nature had gifted him in turning to good account the light which modern science afforded, how much more valuable would many of his positions have been.

If Reid and his illustrious followers be defended on the plea that they were mental philosophers, and were not called to investigate physical laws, we reply that, as regards psychology, this apology is valid. But philosophy, in its wider aspect, knows no such limitation; it avails itself of all accessible knowledge; and in the search for truth, if it voluntarily circumscribes its range, it ceases to be philosophy. This is peculiarly the case in treating of the senses. He who undertakes to explain the phenomena which emerge in the intercourse of mind with matter, must anxiously examine physical facts, or he will not greatly advance our knowledge.

Dr. Porterfield, in his "Medical Essays," and in his "Treatise on the Eye," maintained as a primary law of our nature, that a visible object appears in the direction of a straight line, perpendicular to the point of the retina where the image falls. The form of the retina being a sphere, the lines of visual direction, according to this view, would cross in the centre of the eye: in this view Reid and Bartels concurred. Dr. Smith held that visible direction coincided with the principal ray, or axis, of the cone of light flowing from each point of the object. D'Alembert, Volkmann, and some other men of note, maintained that the direction of vision lies in a straight line, extending direct between the point

of the retina and the corresponding point of the object. They admitted this to be not strictly reconcilable with the laws of optics, but they held it necessary for correct vision, and they conceived it to depend on an inexplicable law of our being.

Sir D. Brewster devoted much care to the investigation of the laws of visual direction, and he convinced himself that the three different lines suggested by the different authors to whom we have alluded, coincide within half a degree.

Sir Wm. Hamilton remarks: "It is marvellous how widely both natural philosophers and physiologists are at variance with regard to the point of the eye at which the rays cross each other. Some place this point in the cornea, some in the region of the pupil, some in the centre of the crystalline lens, and some in the vitreous humour. Recent experiments instituted for the purpose of determining its locality, and still unknown in this country, place it behind the crystalline lens. This is found to be at once the crossing point, both of the rays of light and of the line of visible direction, and the turning point on which the eye rolls." (Reid's "Intellectual Powers," Foot-note, p. 156.)

This is not very distinctly stated. There is not one point at which the rays cross one another. As every point of an object sends out a *diverging* cone of rays to the pupil, to be *converged* on a point of the retina, the different parts of the converging cones cross at innumerable points, and this being the case, the direction of these rays within the eye can afford the mind no information regarding external direction. The axes of *that* cone of light which radiates from the part of the object to which the *axes of the eye* is directed, is the only part of the ray which retains its direction within the ball of the eye unaltered. All those from adjacent parts of the object are more or less refracted from the straight line.

All these investigations to establish the exact course of the rays within the eye, though they have some value in optical science with reference to the laws of light and re-

fraction, they have no bearing whatever on our conceptions of visual direction; and it is a pity the term *visible* or *visual direction* has been used in connection with the determination of a purely physical law, for it has served to mislead even some of our recent writers into imagining that the direction of the rays within the eyes, or the position of the retinal image, affords us an intuitional knowledge of external direction. That the *foci* of the different cones fall upon the retinæ in positions corresponding mutually with the mutual positions of the parts of the external object is well known; and this is absolutely necessary, in order that we may receive an impression of the forms of external objects. But our knowledge of the form of objects is a totally different thing from our knowledge of the direction of the objects.

Sir D. Brewster, in his famous controversy with Professor Wheatstone on *visual direction*, maintained that the laws which regulate our notions of direction are as rigid as those of geometry. Professor Wheatstone, on the contrary, held that the phenomena observed when using the stereoscope, proved that the eye affords no strict criterion, either of the direction of objects, or of the direction of the lines bounding them (*i.e.* of their form). He held that as the images were different in the observer's different eyes, the mind had the power of adjusting the differences so as to produce a one consistent picture, and that this was established by the fact that the different figures presented to the two eyes become, when viewed in the stereoscope, blended into one. In this controversy, in which, on the part of the Scottish optician, there was mingled an acrimony which he afterwards deeply regretted, we feel convinced that the views of Mr. Wheatstone were in part right and in part wrong. They were right, had they been more carefully applied, as having reference merely to the *synthetical conception* which the mind forms of the diverse pictures which the stereoscope presents to us. But we feel certain that the views of Brewster were the true views, in so far as they had reference to the real size and form of the two

figures presented to the mind by the two eyes. In natural vision—in looking, for instance, at a cottage by the way-side, or at a book held horizontally before the face—owing to the different points of view of the two eyes the images thrown on the different retinæ have certain disagreements dependent on the laws of perspective; and in the figures prepared for the stereoscope, similar disagreements are designedly made in order to produce the desired effect. The retinal images, it cannot be doubted, preserve the forms of the figures presented to them, and if these forms are represented in a one common cerebral sensorium, as we have proved to be the case, it is of course impossible that the two *different figures* can be made to coincide physically there, as do the lines and angles in the fourth proposition of Euclid. It is a physical impossibility. The two retinal figures are, we doubt not, for the reasons explained in the preceding chapter, mapped on a common sensorium, and the mind cannot alter either their size or form; and on this ground, and from observation, we hold that Brewster's view is strictly correct.

If, then, there are two images presented to the mind, and these differ in form, how are we to account for the impression which we have of a coincidence of the two images? The answer is this. The mind is practical in all its actings; it occupies itself primarily neither with the coincidences nor with the disparities as such, but with the object as an external reality, having length, breadth, and thickness; and the disparities, instead of causing mental confusion, rather assist the mind in its conception of the object before it. The different figures produce in us the same effect, as if we had taken first a view of the object from the left side, and then another view from the right side, in order that we might know the object more perfectly as a solid body; and thus it is that the simultaneous presentation of the two projections of the object, given in the stereoscope, instead of confusing us helps us to comprehend it as a solid body.

Observe, however, when we withdraw our attention from

the object as an object of vision, and endeavour to compare the lines of the two figures, as given in the stereoscope, we at once discover that these dissimilar lines do not really coincide. It is not, however, always easy to make this experiment, for the mind has a natural tendency to see only congruities in vision, and to reject incongruities, in the report of the two eyes. From this cause we constantly find that when there are apparent contradictions presented, we exclude the one or the other, and thus get quit of the disturbing element. This we have shown to be the case in the experiment with the reversed coins, as seen in the stereoscope (chapter xviii). We may add that we have no doubt that the mind, by acting upon the cerebral or ganglionic centres, is a principal agent in bringing this result about; and that the one branch of the optic nerve is stimulated by a mental act, while the other branch, for want of that stimulus, is kept in temporary abeyance. But, as we have already said, though we find difficulty in distinguishing the figures cast on the separate retinæ, yet we cannot doubt that, both in natural vision and in using the stereoscope, these two figures produce a specific effect, and give us the impression of a solid body.

While we hold that there is no real coincidence of discordant stereoscopic figures, we must not suppose that this arises from any knowledge which the eye possesses of external direction. It appears to us that Sir David Brewster does not keep the two questions distinctly before him, but regards the two as depending on one and the same cause.

As there seems to have been a nearly constant confounding of these two entirely different subjects, we shall endeavour to state the matter as distinctly as possible. Direction is of two kinds, thus—

1st. It has reference to the relative position of two or more parts of an object; in other words, to the figure or form of an object. And of this kind of direction we have an *intuitional perception,* so soon as the eyes and the judgment are duly exercised upon it. It is presented to us by the visual organs.

2nd. Direction has reference to the position or bearing of an object in relation to the observer. It may thus have reference to his body generally, or to any of its parts, as to his shoulders, to his head; or, lastly, and most precisely, it may have reference to the eyes of the beholder, whence it is called *visual direction*.

When an object is at some distance, say to the north of the observer, it is evident that the direction is not changed by the party changing his attitude, and turning his back on it, or lying down on the ground. Its direction is still north of him. Its direction, however, with relation to the different parts of his body, varies with every change of his attitude. It becomes alternately before his face, behind his back, oblique to his figure, etc. This we shall call the *external direction* of the object; and the question is, How do we acquire the knowledge of this external direction? It is evident that it is by experience acquired through locomotion, and not from any property in the eye.

We have said that the eye presents us with a map or picture, projected from the observer's point of view at the time; also that this impression is not perceived in the retina, but in the cerebral sensorium; now, whether this cerebral impression is vertical or horizontal, direct or inverted, neither consciousness nor anatomical skill can give us any information. Such being the case, it is evident that there are no data to enable the mind to form an intuitional judgment regarding the direction of the external object. This judgment then, as we have said, is the result of locomotive experiences.

When a child first scans its mother's face, it can say distinctly, It is *there;* but the question *where* it is—whether in its mind, in its eyes, or in space generally—it has as yet no means of knowing. One of the early efforts of a child, as every mother knows, is the attempt to move its head and its eyes, so as to follow objects which pass before its face. Strictly, these motions are designed to bring the central part of the retina,

which alone is finely sensitive to visual impression, under that part of the retinal image which the child wishes to examine. This is effected either by a turning of the head, or a turning of the eyeballs by means of the ocular muscles. The sensations which accompany these movements can, in the first instance, afford the child no notion of the direction of the outer objects, because the child has no distinct notion of what motions it is accomplishing. It only knows that certain motions make the object clear, and others make it obscure. The next stage, then, is the discovery of external direction. An early exercise of animal life is moving the legs and arms. The child, by stretching out its hands and arms, and touching the different parts of its mother's figure, gradually acquires a knowledge of direction, and learns by degrees to interpret the visual picture of which alone it was originally conscious, and the relation in position which the different parts bear to its person.

The youth who was couched for cataract by Dr. Chiselden, being fourteen years of age, had, of course, a distinct conception of up and down by touch, and by the movement of his arms. After the operation, then, when he raised his hands and put them on the head of the party speaking to him, though he would not at first, by vision, be able to declare which were the hands and which the head, yet the voluntary moving and re-moving of the hands would very soon inform him of this point, and his first lesson on visual direction would at the same time be acquired; for he would observe, by sight, that when he raised his arm it coincided with and touched certain parts of the head, already well known by touch; and when he drew his hands down over the person, he would note how, as visual objects, they shifted their place. The eyes, we have assumed, knew not previously up from down, nor erect from inverted vision; but if it were so, the party, being perfectly neutral as to this, would instantly, or with a speed next to intuitive, associate the true or touch perception of position, both with the visual perception, with

the peculiar sensations in the ocular muscles, and with the varying inclinations he might give to his head.[1]

Then, as regards distant objects, our knowledge of their direction is just an extension of the above experiments. As the rays pass in straight lines from the object to the eye, it follows that when I raise my finger to the line of the distant object, the point of the finger and that object are seen to coincide, and the impressions of the two objects at the same time coincide on the retina and in the sensorium. And thus, after we have acquired our first infant lesson on direction by actual touch, the direction of the finger becomes a true and precise index of the direction of the distant object.

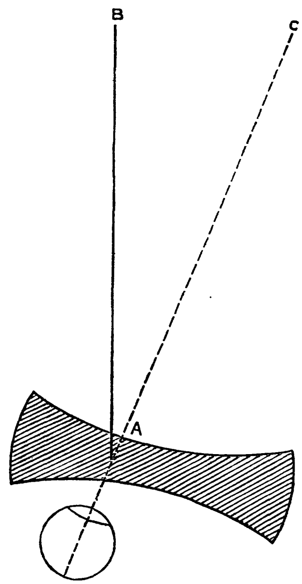
Direction has a conscious reference, however, to all parts of the observer's person. When we see a landscape or any smaller object, we know by experience that it is before us and not behind us; we know which parts are upwards and which downwards, which to the right side and which to the left. We have a vast variety of concurring helps to guide and confirm us in our knowledge of direction. In order that we may have a clear perception we must turn the axes of the eyes to the object; this is effected by a movement either of the head, or the eyeballs, or of the whole person, and it is easy to see that we shall ever after habitually associate these known movements, and the resulting direction of the eyes, head, and shoulders, with the direction of the object we are looking at.

The course of the various axial rays from the object to the retina is nearly that of straight lines. We occasionally find, however, that the lines may be considerably bent without any great practical inconvenience, and thus we obtain proof that our sense of direction is mainly founded on touch. If I am practising with the rifle while wearing spectacles for short-

[1] Cataract does not generally exclude all perception of light. The patient, by passing his hands up and down and across in front of his eyes, and thus causing the shadow to affect the retina in different ways, has usually the means of acquiring a pretty distinct notion of the visual direction of his hands.

sight, and have by accident drawn them a little to the right side of the face, the ray from the distant object is thereby bent to the left side, and the image falls in that direction, so that in order to see distinctly I have to shift the centre of the retina (the *fovea centralis*) to the left. The judgment I form, founded on this experience, is that the object lies not in the line A B, but to the right, in the dotted line A C. I am therefore inclined, by a false visual judgment, to aim too much to the right side; but my rifle, my hand, and arm, the target, and all surrounding objects, are *seen* as if equally shifted to the right; and so, guiding my hand by what I see, I take my aim in the proper direction, A B, for thus only can I cover the object B with my rifle. This discordance between my eyes and my arms gives at first some disturbance, but in a short time the inconvenience ceases to be felt.

Fig. 41.



In the case given we ask, Where do we perceive the object to be? From the position of the eyes we form one judgment, and a wrong one, for we are looking not towards the object, but away from it by several degrees; but by the felt direction of our arms, and of the rifle, we are enabled to form another and a correct judgment. Our knowledge of external direction is thus clearly, not an intuition given us by the eye, but a judgment founded on the agreement of various tactual, sensational, and locomotive experiences.

Although, however, tactual experience, and the known direction of the eyes and head in looking at an object, give us the knowledge of external direction, yet we must keep in mind that this knowledge, being acquired, the perception

of the *relative* positions of the different details of complex objects, as given by the image, or visual presentation, is of the very highest service; it is indeed the chief means of keeping us abidingly impressed with the position of the various parts. For as we know by experience that the part of the landscape to which we direct the axes of our eyes lies in that direction, so, knowing this, we necessarily know the position of each separate part, both in relation to the central point of view, and in relation to the observer.

One other observation we have to make before closing this already too much extended chapter. The mind can only attend to the details of one minute object of vision at a time; and the more intently we concentrate the attention on it, the more certainly shall we usually be found to direct, not only the axes of the eyes, but also the head, shoulders, and whole person towards it. And we think it will be observed, that just in proportion as the observational energy lessens, and the reflective energy increases, do we naturally turn the head aside, and look not so much *at*, as *towards*, the object. So much is this the case, that the act of turning the head or neck slightly to the side, and casting the eyes obliquely, is the appropriate sign or symbol of observational reflection; which mental state it would seem is incompatible with an intense and concentrated observational attitude.

We have only further to mention, that there is a point in each retina which is insensible to light. This fact was discovered by the Abbé Marriotte. The insensible point occurs where the central artery and the optic nerve enter the globe of the eye. In directing both eyes to an object, the image, though it may fall upon the insensible point of the one eye, cannot, in consistence with the natural direction of the axes of the eyes, fall on the insensible point of the other eye; no inconvenience is therefore experienced. We may, however, convince ourselves that each eye possesses an insensible point. Let the left eye be closed, and

O **X**

the right eye be intently directed to the letter O, held in front of the open eye at a distance of five inches; the letter X will be found immediately to disappear, and will continue invisible so long as the eye is kept steadily fixed on the object to the left; so soon as the slightest movement of the eye is made, from inattention or otherwise, the object to the right will start into view. In like manner the letter O will disappear when we shut the right eye and look at the letter X with the left eye at the proper distance.

CHAPTER XX.

THEORY OF VISION (*Continued*).

OCULAR SPECTRA—PHYSIOLOGICAL CONDITIONS OF THE RETINA—COLOURED SPECTRA—HARMONY OF COLOURS—IRRADIATION OF SENSATION—HOW ITS DISTURBING EFFECTS ARE OBVIATED.

TO understand the philosophy of vision, three things entirely distinct are to be considered.

First. The external physical agent, and of this we have treated in chapter vii.

Second. The action produced in the living organism; and,

Third. The *result*, viz. the mental phenomena of light and colour.

The subject of ocular spectra, as treated in this chapter, will help to illustrate the theory of vision; for we shall see that a movement or excitement in the organ of sense, and in the nervous centre, produces, and keeps before the mind for a considerable time after the external cause has been removed, all the impressions of vision. The subject of ocular spectra thus forms a natural stepping-stone, as we pass from the *material* to the *mental*, and it therefore finds its proper place towards the end of this section of the volume.

Let it then be kept in mind, that vision is not caused by the entrance into the eye of any material substance resembling light. Neither is it, in strict language, the perception of anything external to us. It is a mental condition induced by the excitement of the sensorium, by mechanical impulses on the retina. In other words, it is a subjective affection, though produced by external agencies.

Let it also be remembered, that *colour* depends on the nature of the excitement, namely, on the size and rapidity of

the vibrations which impinge on the retina; and white or colourless light depends on the due combination of the undulations peculiar to the primary colours.

It being thus premised that the sense of light and colour is the result of impulses on the retina; and it being also understood that the retina is one of the most sensitive membranes in the human frame, and the most easily excited to action, we shall be disposed to admit various consequences as likely to ensue. These we may state in the form of postulates which commend themselves to our acceptance, and in this way a somewhat intricate series of phenomena will be made plain and intelligible. Thus let it be admitted:

First. That if the retina be excited by any cause of sufficient force or vivacity, the excitements may continue a considerable time after the exciting cause is removed; and thus that an impression of the object may be perceived after the object itself is withdrawn, and the eye is closed, or shaded by the hand; and that this continued action of the retina may gradually subside, and the spectra become more and more faint till they entirely disappear; and that in fading away they may show a tendency to pass through various changes, assuming successively the less luminous colours.

Second. Another effect of this condition of the retina, may be this. That the retina being kept in action by any continued excitement of a *specific kind*, it may, according to a law of nervous action, experience a species of fatigue and become partially insensible to the particular stimulus which has excited it, though it may continue sensitive to excitants of a different kind. Thus it may become more or less insensible to the impression of one colour, while it is perfectly sensitive to the impression of another colour newly presented to it.

Third. That if the excitement of the retina has been considerable or long continued, the vital energizing substance of the retina may have a tendency to a reactionary movement of *an opposite kind.*

Fourth. Other effects may also be anticipated in this

sensitive membrane; thus, on the occasion of a continued excitement of a considerable portion of the vital substance of the retina, the action raised may be propagated to adjoining parts. It may happen, however, that the action raised in the adjoining parts of the retina may be, not of a similar, but of an opposite or modified kind. This influence on adjoining parts may be denominated the *irradiation* of sensation.

These conditions of the retina, if admitted to be probable or likely, will be found sufficient to explain nearly all the phenomena of ocular spectra. Any one of the above conditions may either exist alone, or, as is most frequently the case, the retina may, at the same moment, be the subject of more than one of these influences. This will consequently complicate the phenomena observed.

Before giving examples to illustrate the conditions above mentioned, it may assist us if we have before us the accompanying diagram.

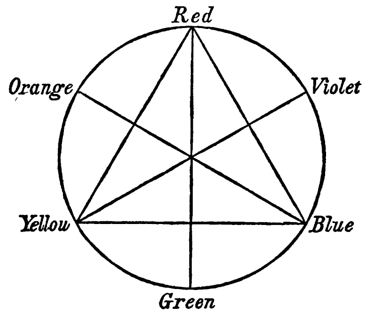
Whatever may be the colours which constitute the real elements of solar light, which is still a matter of doubt, yet, for our present purpose, the three pure colours—red, yellow, and blue—may be held to be so, inasmuch as when duly combined they produce colourless light; and also because, as will be seen in the diagram, these colours in binary combination produce the intermediate colours—orange, green, and violet. The colours—red, yellow, and blue—have therefore popularly been held to be the pure or primary colours, and the intermediate three, the mixed or secondary colours. And we need not here distract our attention by considering the arguments which have been employed against this theory.[1]

Any two of the colours in the diagram which are placed opposite, are considered in this connection *complementary colours*. Thus the red and green, the orange and blue, the yellow and violet, are complementary colours, as they contain the three pure colours, which in combination constitute white

[1] Helmholtz considers red, green, and violet as the primary colours.

light. And in fact, when any two pigments of these colours are mixed together, they produce a grey colour, which would

Fig. 42.



be white were it not for the impurity of the ingredients employed.

These opposite colours are also called, with reference to one another, *accidental colours*, because in all cases of coloured spectra they either accompany each other, the one forming the centre or body of the spectrum, and the other the surrounding fringe; or if one of these colours has been the object exciting the retinal action, the other, which may be called indifferently the opposite, the accidental, or the complementary colour, generally appears as the spectral colour. This nomenclature being understood, we proceed to state some of the more common examples of spectral images.

We shall state them in the order we have adopted in postulating the conditions of the retina, on which they are supposed to depend, and the reader will thus be the better able to connect the one with the other.

First. Lay a small piece of white or green paper, an inch and a half in diameter, on a black ground, and fatigue the retina by gazing intently at a small point in its centre for, say, half a minute; if the eyes be then shut, and at the same time shaded with the hand, a light-coloured image, if the paper has been a pure white paper, will appear. If the paper has had a tinge of blue, or if it be a green paper, a dull reddish or pink-coloured spectrum will be the result.

If the experiment be varied by laying a black piece of paper on a white surface, a spectral representation of the black spot, and white or light-coloured ground, will float before the eyes, when they are shut and shaded from the light. Here the parts of the retina which have been left in repose produce the spectral image of black, which implies an absence of all excitement, while the surrounding white is due to the action of the white ground.

The spectra produced by gazing on the setting sun are, as may be expected, much more vivid than those which arise from looking merely at coloured objects. They can scarcely have failed to attract the attention even of the most unobservant. On shutting the eyes and entirely excluding light, even through the eyelids, after looking at the sun, the spectra may be any of the colours of the diagram, or any combinations of them. Generally they will, at first, be a bright yellow, and by degrees, as the impression subsides, they will fade into the less luminous colours of orange, red, violet, and green, and will finally disappear altogether. These vivid spectra will generally have complementary fringes, from the action induced on the surrounding parts of the retina.

Second. If instead of shutting the eye we turn it to a white surface, as to a white cloud, or to a sheet of white paper, which contains all the primary colours in combination, the spectrum will probably at first be the bright yellow colour of the sun; by-and-by, and generally very quickly, however, as the excitement fades, it will either appear as a dark grey spot upon the white cloud, or it may have any of the colours of the diagram, or any combination of them; but in this case, with the eyes open, as the impression dies away, and the eyes gradually recover the power of being affected by the rays from the white surface to which they are directed, the colours of the spectra will successively shift from the duller to the more luminous colours,—from the grey to the blue or violet or the green,—and will usually end with a beautiful light pink, as the retina recovers its normal tone.

Another variety of spectral phenomena explicable under this second supposed state of the retina is this: If we fatigue the eyes by gazing at any of the colours of the diagram, and then turn them suddenly to a sheet of paper of any of the complementary colours, this complementary colour will seem to acquire an unwonted brilliancy and purity. Thus, if we fatigue the eyes with looking at a green colour, and then turn them to a red surface, the latter will immediately seem to acquire the most brilliant red tone of colour. The reason of this is, that all artificial colours contain an admixture of white and other colours. The eyes, then, being first fatigued by the green colour, which is probably compounded of yellow and blue, it becomes insensible to these colours, which exist more or less in the red paper, and it is thus rendered capable of seeing the red in its purity. This makes the red more brilliant than we are accustomed to see it in any other circumstances.

The experiments with coloured wafers, laid either upon a white or on variously coloured surfaces, are well known, and illustrate this peculiar law of the retina. By shifting the eyes from the wafer to the coloured surface, the complementary colours will invariably appear in great brilliancy, and even if we turn from the coloured wafer to a white surface, the complementary coloured spectrum will appear, though by no means so bright.

Third. We may illustrate the third supposed condition of the retina by referring to the fringes seen round solar spectra.

Fourth. To illustrate the condition of the retina above supposed. When we examine, for any length of time, a minute object lying on a different coloured ground, as, for example, a small dark spot, on white paper, the object while we gaze will suddenly disappear. The excitement raised by the white paper on a more extensive portion of the retina, diffuses itself over the smaller adjacent portion, and obliterates the minute object. The same result ensues when we strain the eye to perceive a distant object of small size. The more steadily and intently we look, the more sure are we to find the object elude our

gaze: it appears again, and is again extinguished, defying us to fix it steadily The sportsman, in endeavouring to follow his game, and mark where it alights, is frequently baffled by this action of the retina. He charges himself with want of attention, when it is a physiological law of vision he is contending with. This tendency of a predominant portion of the retina to diffuse its action, produces also a more pleasing effect; it causes the prevailing colour of the landscape to soften down our perception of the more minute and trivial points which occur in it. While thus adding to the mellowness of the general effect it diminishes, however, in a corresponding degree, the distinctness of detail.

Such are the principal instances of ocular spectra. From the explanations given, it will follow almost of necessity that when the eye becomes fatigued by the too protracted excitement of any one colour, it will experience a refreshment by the entrance of an opposite colour. Painters understand the practical results of these physiological laws, and avail themselves of them, to heighten their effects by contrasted colours, or to subdue unpleasant or over-predominant hues, by introducing, in some part of their canvas, a well-selected colour, sufficiently strong to mellow down the obnoxious tinge. In portrait painting this is easily managed: there is the ready remedy of a curtain of any desired colour by power of contrast, to give vivacity to the complexion, or to subdue a false tone. In landscape, there is always a latitude allowed; and, whether from earth or heaven, the artist will borrow a light to conceal any unhappy work elaborated on his canvas with ill-selected colours.

There is a harmony in colours as in sounds, and there are also discords; and though some have pushed the analogy between sound and light to fanciful lengths, attempting to show that the same mental laws regulate both, we are disposed to take a less extreme view, and admire the coincidence by which those contrasts of colours and of sounds, which are

refreshing to the *eye* and to the *ear*, are also, at the same time, gratifying to that faculty of the *mind* which gives us the perception of grace, beauty, and variety. Harmony in sound, in colour, and, we may add, in figure, is dependent on the law of proportions. By turning to the diagram, we shall see how strictly this is the case with colour. Those colours which constitute white light are always harmonious when associated together; thus the pure colours—blue, yellow, and red—are bold, but not disagreeable in nature when contrasted; or the mixed colours—orange, green, and violet—are also good contrasts when existing together; or red and its opposite green; yellow and its opposite violet; blue and its opposite orange. The unharmonious contrasts are such as contain only a part of the constituents of white light; thus red with yellow, or red with blue, or yellow with blue—these are the most decided *disharmonics*, and are universally held as offensive to taste, and unrefreshing to the eye; the discord may, however, be resolved by introducing the absent colour. The discordant effect may also be partially relieved by bringing in a third colour, which is a harmonic to either of them; thus, red and yellow are disharmonic: they are, however, harmonized by the introduction of green. And this, it may be remembered, is the variegation which autumn throws upon our woodland scenery. Again, we have another instance of the resolution of disharmonic colours by introducing violet, which relieves the unpleasant effect of red and yellow, or of red and blue. Red, blue, and green are for the same reason not unpleasing.

There are some combinations which are usually considered as neither pleasing nor displeasing, namely, the association of two colours of which one forms the transition to the other, as shown in the diagram; thus, yellow and green, red and orange, violet and blue.

It will be observed that all these peculiarities of vision, which we have described under the name of spectra, arise either from unduly protracting the excitement of the retina

by any one colour, or from applying an over-active stimulus. They must all be noted as hindrances to the perfection of the sense of vision, and they would become seriously embarrassing were it not that nature has provided a partial counteractive. Sir Charles Bell, in his "Bridgewater Treatise," alludes to it with peculiar satisfaction. He observes that the eye does not naturally dwell long upon one object, but keeps involuntarily shifting from point to point. This constant searching motion is essential to clear vision; it not only brings the image of the different objects successively upon the more sensitive portion of the retina which lies in the axis of the eye, thus enabling us to examine the details distinctly, and ascertain their shapes, sizes, and positions, but it also serves the important purpose of preventing any one colour from resting too long on one point of the retina, and producing the disturbing effects which we have been alluding to. Bright colours are thus prevented from fatiguing the eye and exciting spectral representations; the *irradiation* of sensation is also avoided, and widely diffused colours are prevented from overpowering minutiæ in the landscape which it is desirable to retain.

CHAPTER XXI.

TASTE.

TASTE—ITS VINDICATION—ITS ORGAN—THE TONGUE—ITS VARIOUS OFFICES—ITS PAPILLÆ—CRAVINGS OF THIS SENSE—ITS EFFECTS ON THE HUMAN RACE—EXTENSION OF MAN'S BILL OF FARE—ITS UNEQUAL PROGRESS—CLASSIFICATION OF TASTES.

BEFORE considering that sense whose office is to give us a knowledge of our frame as an extended solid substance, and which acquaints us with the well-being and the sufferings of its various parts, we shall consider two senses whose nature and whose duties are widely different from this; whose organs, unlike the organ of touch, are circumscribed to very narrow areas—senses which, strictly speaking, know nothing of touch, or extension, or solidity, but whose actions and perceptions have much more of a chemical character, letting us into an acquaintance with certain of the more hidden qualities of matter.

Some are disposed to rank this sense of taste as of a lower cast, deeming there is about it something sensual and degrading. Although it has, like all the other senses, been too frequently abused by excessive indulgence, this is no reason for severe Platonists disparaging it in the exercise of its legitimate functions. As it is the sense having the custodiership of the animal wants, so, in the exercise of this charge, there is no sense more largely contributory to every-day enjoyments, animal spirits, health, and comfort. We may, moreover, say this for it, that what it lacks in the *intellectual* is more than countervailed by what it contributes to the moral and benevolent. Besides its proper and express office of gently drawing our attention to the animal wants, and with a nice discrimination deciding on what is useful

and what injurious, there are clustered round it a large share of the bland and beneficent virtues of social life. The carnivora alone, beasts altogether savage, drag their prey to a corner to indulge a selfish appetite. Man, and the more amiable animals, choose to eat in company. Sympathy in one another's enjoyments is one of the kindliest gifts conferred on man, and it is no less to be esteemed because shared by him and the lower animals. It shows itself among them, not only in social feeding, but in many other shapes. The back-galled horse lifts a sleepy head from the grass to view the gambols of his younger associates ; standing like a stock, twitching his broad, drooping under-lip, he gazes with a good-natured comical expression upon enjoyments in which he cannot join. But it is in the indulgence of the sense of which we now treat that animals enjoy the most certain and frequent sympathy, and the exhibition of it, far from degrading, adds a charm even to natural scenery— "Russet lawns and fallows grey" would be cheerless and lifeless were it not that over them "the nibbling flocks do stray." When grander features are awanting, there is not a more satisfactory sight than the bare observing of this sense in exercise ; for instance, the solitary ox, applying his broad nose to the sward, while short, strong blasts from his nostrils indicate the energy and extent of his gratification. This social principle among animals is strongly implanted, and rather than miss it, when more fitting congeners cannot be found, it draws into alliance animals of the most different natures : thus the hen will follow the cow, and the solitary sheep will keep close by the heels of the horse. Although no word is exchanged, the responsive short crop, crop, is held sufficient intercourse and enjoyment.

Man is not above this influence, nor should he be. When the body is exhausted by fatigue, and the head perplexed by business, or the temper ruffled by the vexations of life, we become aware how intimately the mind and body are associated : the wear and tear of the latter must be repaired,

or matters will get worse. The social meal affords the appropriate restorative; it changes the current of thought no less than the current of the blood congested in the over-wrought organs; it forms the most pleasing and the most effectual alterative, and, under its medicinal influence, difficulties and disagreeables are overleaped, or viewed in a happier light.

What sort of monstrosity would man become—our lawyers, for instance, the practitioners in our law-courts, these men of strife, and struggle, and technicality; or the merchants or shopmen, or any one of the organs of civilized society, did they not allow themselves occasionally to melt from machines into men, and get the professional wrinkle smoothed under the operation of the social glow?

Thus is sense made a sweetener of society, and an ameliorator of the human race. It is also a quieter of feud; for the man who can eat with another, and yet secretly lift up his heel against him, breaks the established code of all nations, and is righteously branded as a traitor. The British nation is charged as being over addicted to this sense. It may be so; but with the evil is wrapped up the attendant good, and it is hard to tell how much even of our national greatness rests upon the solid foundation of our dinner-eating propensity. Our after-dinner discussions disengage a great deal of valuable and easy dialectics, and give a practical turn to our minds which is strangely awanting across the channel. We learn to know one another's virtues, and to pardon one another's foibles. A certain sobriety of thought is begotten, which enables us to tolerate political differences in those we meet, and teaches us how much more is to be gained by good nature than by argument or high-blown sentiment. Could our Gallic neighbours be brought to this pass—to abandon their political clubs and submit to the dinner-eating usages—there is no saying what ameliorations might follow in the train. If the change should deprive the world of some eloquence, and the orator should lose that chief reward of aspiring politicians—*the sensation in the senate-house*—in their place might

come some more solid advantages, and perhaps we, their sincere well-wishers, might be spared witnessing the recurrence of those frequent ungainly steps from the sublime to the ridiculous which have distinguished the movements restless, self-confident, and talented neighbours.

The seat of the sense of taste is in the tongue and palate, but especially in the former. The tongue in fishes and in most birds is hard and stiff, and it is probable that their sense of taste lies principally in the fauces. Serpents swallow their prey entire, with the natural covering of hair or feathers ; and we may hence infer that the sense of taste is awanting in these animals, and that they are assisted by smell alone, or by a particular instinct, in the selection of their food, their appetite or impulse to eat being prompted by the pains and agonies of inanition.

The excitant to this sense is the nutritive matter received into the mouth, and it is essential, for its properly acting on the organs of taste, that it be reduced to pulp and dissolved in the saliva supplied by the glands with which the mouth is furnished, and which, under the operation of mastication, and the stimulation afforded by the presence of agreeable food, pour out their secretion in abundance. Besides diluting the soluble parts of masticated food, and so allowing it to act upon the nerves of taste, the saliva commences the first part of the process of digestion, and without doubt assists in the solution of the more obdurate parts previous to their descent into the stomach. It especially possesses the power of converting starch into sugar, and this is doubtless the cause of the peculiarly sweet savour which bread has in the mouth of all who have not destroyed their natural taste by the constant use of highly seasoned food. It is supposed also by Liebig that the air, so largely suspended in the saliva, being carried to the stomach, supplies oxygen, which is taken up during the conversion of food into chyme.

The organ of taste is of course supplied with a special nerve for the fulfilment of the functions of that sense. It

seems now to be ascertained that the lingual and palatial branch of the fifth cerebral nerve, and the glosso-pharyngeal nerve, which supplies the back part of the tongue, are the special nerves of taste. Besides these nerves, the tongue is supplied with another pair of nerves, namely, the hypoglossal, or ninth cerebral nerve, which supplies it with motor power; also with a nerve of common sensibility.

There is not, perhaps, a more curious and more highly gifted organ in the body than the tongue. It is at once possessed, as we shall see, of the finest sense of touch. Unfettered by any joint, it has the most endless and complicated powers of movement throughout every part. One object of this mobility is the adjustment of the food between the grinders, an office for which the feeble but dexterous employment of its limited strength is perfectly sufficient. Though placed in so perilous a situation, where the work of grinding and destroying is carried on all around, and with little room for it to clear itself of the formidable machinery, by its lubricity and fine touch and powers of motion, it plies its office with unconcern, rarely meeting with an accident. Its higher function is as the principal organ for moulding into articulate speech the sound issuing from the throat. Many attempts of ingenious mechanists have been devoted to produce a machine capable of pronouncing a very few recognizable syllables, but the success has been very indifferent. The tongue, however, by its exquisite and universal muscular movements, which seem almost like vibratory movements, moulds the simple note which the larynx produces; and even when the energy of the orator is pouring forth sounds quick as the ideas press themselves upon him, this little organ allows not a breath to pass without transforming it into the desired intelligible shape. It is difficult to decide whether the ear which receives and discriminates these rapid and various signs, and hands them to the mind to interpret their significance, or the tongue which fashions and throw them off, is the more wonderful in its office.

As an organ of taste, the tongue is covered with a membrane thick and vascular, which bears upon it nervous papillæ of three kinds. The first or large papillæ are from three to thirty in number, and are arranged at the back part in two rows like the letter V, with the apex backwards. The second kind are fungiform or lenticular in shape, and are spread irregularly over the greater part of the tongue. The third kind are cuniform, and cover the remainder of the surface and sides; they are thickly set, and point backwards. In carnivora these papillæ are hard and sharp, and serve the animal in tearing off the flesh and tendons from the bones. In oxen they enable the animal to lay hold of the grass. These papillæ are vascular, and contain the terminations of the nervous filaments, which are thus brought into proximity, though not into contact, with the substance under mastication. The contact with the papillæ is rendered more intimate by the pressure and rubbing of the tongue against the palate, and this motion, as in the sense of touch, increases the sensibility of the papillæ.

Man, who of all animals is most artificial, has by peculiar culture extended the discriminating exercise of his senses, and, as might be expected, has greatly altered the natural cravings of this one. He has ransacked the earth for a variety of comestibles, and he uses a great many that are abhorrent to all other animals. Some of the articles in principal use, the natural taste has, it is certain, no craving for. Such are spirits, tea, porter, and many bitter and nauseous substances. When the taste, however, for these has once been acquired, the stronger, it is observed, and more inveterate becomes the relish for them. The reason is, that they are generally either stimulants or alteratives, and possess those active properties which, under the effects of enfeebled appetite, the sense demands.

Herbivorous animals, confined to artificial grasses, seek also anxiously after variety in food: fences will scarcely keep them in. They greedily mouth every green thing, even such

as are poisonous, as the yew-tree, and thus frequently fall victims to the passion. Man, however, has the craving in a stronger degree, and seeks the gratification of it with more persistence and method. As new countries are discovered their natural productions are examined, and whatever is available as a condiment, or an article of nourishment, is hailed as an addition to his wealth; and deservedly so, for wealth consists not merely in gold, or lands, or mills, but in whatever is available for our comfort and enjoyment. The craving for excitants to this sense has produced the most remarkable changes in the staple of human food; and these changes are cognate with the most important national and mundane events. The history of the extension of our bill of fare forms in great part the history of our colonies and our commerce. The desire for various viands has covered the sea with ten thousand sails, has carried the white man from his natural zone and has planted him in almost every corner of the torrid regions. Wherever nature's vegetable productions are poured forth in richest abundance, there he is to be found pursuing his aggrandisement by catering to this his appetite for variety in food. The result of this co-operation is, that a citizen of the middle rank in the nineteenth century can treat his friends to a variety of dainties which would have shamed the table of Lucullus, and this at not a hundredth part the cost which has rendered illustrious that boastful Epicurean.[1]

It is curious to reflect how large a portion of the food now in chief use in civilized nations was entirely unknown to the ancients. Sugar, an article now judged so indispensable, was first tasted by the crusaders in the beginning of the twelfth century. A few thousand pounds of tea supplied all the wants of the united kingdom in the time of good Queen Anne. Coffee, which since 1825 has made such rapid way in

[1] This famous three-handed supper, at which Cicero and Pompey were the sole and self-invited guests, though improvised on short notice, was doubtless a very show-off affair. Plutarch on popular rumour states the cost at 50,000 drachmas —this in corresponding weight of our silver would be upwards of £2000.

Great Britain, was, in the beginning of the last century, only known as a curious plant growing in the botanical garden at Amsterdam.[1] Alcohol, extracted by chemists from wine by distillation, is described by Arnoldus and Raymond Lully in the thirteenth century as a recent discovery, and the probable *elixir vitæ* so long sought after by the alchymists. We owe both tobacco and the potato to the eventful expedition of Sir Walter Raleigh to America in 1584. The former and less worthy plant gained rapid favour; the more useful potato slowly struggled into public esteem. It was exhibited in our shop-windows merely as a worthless curiosity no further back than a hundred years ago; and it is only during the last fifty years that it has gained anything like a firm footing on the continent of Europe.

Perhaps we should deplore that so many of our new discoveries are but stimulants; the tendency of civilisation seems unfortunately too much in this direction, to seek for excitants for mind and body. Our ancestors were roused from apathy by the stimulants of war and beer. These are now quite insufficient. Our pampered and fastidious tastes must be encouraged to action by an endless catalogue of condiments and spices, and the mind of the busy trifler be relieved from ennui by a never-ceasing supply of politics, poetry, novel-reading, and platform exhibitions. The philanthropist may sigh for the more rude and healthy animal tone of primitive times; but such, alas! cannot be brought back but by the overthrow of our knowledge, and activity, and national wealth, and by a forced retreat to ignorance and barbarism. One only hope therefore remains, namely, that under the influence of reason and self-restraint we may yet be enabled, notwithstanding the increased temptations that surround us, to achieve a triumph over ourselves, and make all these bounties of Providence keep their proper place, and by their restricted use be made subservient to our health of body, and well-regulated enjoyments.

[1] The consumption of coffee in Great Britain, in 1824, was 8,262,943 lbs. In 1872 it exceeded 48,000,000 lbs.

There exists a great difficulty in classifying or describing different tastes; which is also the case with smells. Plato and Galen reckoned seven different simple tastes; Aristotle and Theophrastus, eight; Boerhaave and Linnæus, ten. But on the subject of scientific classification we shall not enter.

There is, by almost general assent, a close and sometimes indistinguishable correspondence between the sense of taste and that of smell. Smell is principally exercised upon the articles entering the mouth, and in man, but much more in the lower animals, it exerts a preliminary scrutiny on them. It is natural, therefore, that the sensations of the two senses should become closely associated in our minds, and in some cases be undistinguishable. From this cause it is that, when some of those articles which are employed to season food, such as cinnamon, nutmeg, cloves, and some other spices which possess no taste are chewed along with our food, we find it difficult to persuade ourselves that it is not the organ of taste that is regaled, although the pleasing sensation is entirely due to the flavour of these spices.

CHAPTER XXII.

SMELL.

SMELL—ITS OFFICE—ITS FIELD—PRINCIPLE OF REPULSION EXHIBITED IN THE MOLECULES OF BODIES—SMELL CONVERSANT WITH THESE—ITS RANGE OF PERCEPTION—ITS NERVE—ITS OFFICES—ITS SUGGESTIVE POWERS—ASSOCIATED WITH THE LUDICROUS.

WHILE the nerves of taste have to do with substances presented to them in a fluid or pulpy state, the sense of smell has the atmosphere as the field of its investigations, and its office is to analyze the qualities of such ingredients as may for the time exist in it. The tongue requires the substance under examination to be spread grossly over its surface. The nose, whose sensations are sometimes confounded with those of the neighbouring sense, possesses a keener and more subtle perception ; it applies itself to the detection of those minute and invisible molecules which almost all bodies throw off from their substance, and which for a time hang suspended in the atmosphere. For this purpose the organ of smell is connected with the respiratory system, which enables us at will to draw properly regulated currents of the air to be examined through the passages leading to the olfactory apparatus.

It is well known that all fluids and many solid bodies, when exposed, undergo a rapid evaporation. These bodies exist therefore in the air as elastic vapours or gases. The experiments of Dalton led to the conclusion, that vapours of all kinds, and the various gases which exist in the atmosphere, interpenetrate each other, as if each gas or vapour obeyed a principle of elasticity peculiar to itself, the molecules of each

repelling only those of its kind, and being indifferent to those of other gases with which they are associated.

The existence of this tendency to diffusion among the molecules of bodies, solid and fluid, is a very singular circumstance. It was long supposed that, though the great law of attraction which binds the atoms of matter together still held good, there was, at the same time, an action of a contrary nature at work, which caused the molecules of bodies to quit the solid or fluid state, and freeing themselves from the mass to assume something of the aeriform condition. The old belief in repulsion it would seem has, however, been overthrown by a new theory; and the apparent self-repulsion of aeriform bodies is now pretty generally ascribed to the dispersive action of ethereal vibration. The particles of the atmosphere, and of all vapours and gases are, by the rapid motion of the ethereal medium, said to be so acted on as to be kept in a constant state of motion and separation, and to be caused to dart hither and thither, with a velocity which is nearly equal to that of a cannon-ball. The trajectory of the particles is, however, a very short one, being stopped by the constant impact of one molecule on another.

It will be seen that this impulse from so many darting bodies will be quite sufficient to account for the apparent elasticity of gases and vapours, and also for the law of mutual penetration, of which we have been speaking; and for the visible expansion of smoke wreaths which we witness even in the calmest air.

With regard to aqueous vapours, it has long been known that their density, where the means of evaporation are at hand, bears a constant proportion to the amount of heat at the time, and it is by the operation of this law that our atmosphere becomes alternately penetrated by watery vapour, and disburdened of it by rain.

The same ethereal vibration is the cause of the existence of all the odours which perfume the air. It is not only fluids

that obey this law; a vast variety of solids are also caused to throw off their molecules. Ice and snow do so no less than water; many metals, such as brass and copper, exhale a strong smell, especially when rubbed; and most stones when struck with a chisel emit a peculiar pungent smell.

An insensible exhalation is constantly going on from the bodies of living animals and is carried through the air. It is well known, however, that dogs are all but insensible to the presence of birds which have been dropped and have lain even a few minutes on the heath.[1]

Animal and vegetable substances, when prepared by heat, throw off the well-known flavours which we relish in our food; on the other hand, these substances while undergoing putrefactive decomposition, and assuming the inorganic form, resolve themselves into gaseous compounds, most of them injurious to the health, and luckily also offensive to the sense of smell.

The exceedingly diluted state in which some bodies may exist, and yet be detected by this sense, whose testing power far exceeds that of chemical analysis, must give us a high impression of its sensibility. A grain of musk will for many years perfume an apartment, giving off particles sufficient to scent the atmosphere of the room several times in the day and without the substance being perceptibly diminished in weight.

And here we may allude to a peculiarity in the structure of the organ of smell, in order to point out how wisely nature, as it were, anticipates peculiar difficulties, and provides for their mitigation. The olfactory lobes rest close upon that part of the floor of the cranium which is called the *cribriform* plate. This plate is perforated like a sieve, and it is through these perforations that the filaments from the olfactory lobe are sent down in immensely numerous threads into

[1] The exhalation seems also to cease during incubation. We have known of a pheasant sitting undisturbed on her eggs, on a piece of ground intersected by two roads, constantly traversed by men and dogs, and within less than two yards of the point where the roads crossed.

each division of the nose. These olfactory filaments are diffused throughout the mucous membrane which lines the upper part of the division of the nose, and over the surface of the chambers formed by the convolutions of the upper and middle turbinal bones of that organ. Now, though these chambers or cavities have a communication with the direct passages through which the air from the nostril is drawn, yet the current does not pass through them; at first this might surprise us, yet the reason is almost apparent if we keep in mind the nature of the sense of smell. Its office is to detect the diluted and impalpable foreign substances which casually exist in the atmosphere; and the faintest and almost uncertain indication of a taint in the air is frequently all that can be perceived. The office of the olfactory nerves is thus a very delicate one, and requires every possible advantage for its prosecution. Two formidable obstructions suggest themselves to us as likely to defeat this object unless provided against. Were the currents of air allowed to pass directly through these nerve-lined cavities, the moisture of the mucous lining would be thereby dried up, and the sensibility of the surface would be materially impaired; and, second, the current of cold air thrown against the nerves would excite various affections of general sensibility by its mechanical impulse, and would materially disturb, if it did not overpower, the finer perceptions of the nerves of smell. The olfactory cavities are therefore, as we have said, merely accessible to the air drawn through the wider adjoining passages, and are not directly exposed to its stronger currents. By this arrangement we may understand how a portion of the air to be examined will, at each inspiration, diffuse itself quietly and at the natural temperature of the body in the chambers, and how the nerves will thus be in the most favourable position we can imagine for being acted on by the very subtle impulse implied in the contact with these invisible and impalpable atoms which they have to detect.

In animals distinguished for their acute sense of smell, the expansion of the olfactory nerves is proportionally great, and the ethmoid and turbinated bones over which they are distributed occupy the greater part of the animal's face. Additional branchings and convolutions of the thin plates of these bones affording, in these animals, an extended surface to the nerve.

Man is perhaps less gifted with acuteness in the exercise of the sense of smell than most other animals. This is in consistency with his higher intellectual nature. Had he the scent of the dog, his head would be bent towards the ground, and his mind would be drawn to sensuous objects, and distracted from the exercise of its higher pursuits. The scent of the bloodhound and retriever in tracking foot-prints, and of the pointer in discovering game, surprises us almost into the belief that they have a sense additional to those possessed by us. Man, however, though less acute, possesses in the exercise of this sense, as well as in all the others, a wider range of perception than the lower animals. It has been held by some, that the carnivora are only conscious of animal odours, and that the herbivorous animals are insensible to animal exhalations: there is, undoubtedly, some difficulty in ascertaining how far this statement is correct. All we can from experience affirm is, that as animals exercise this faculty chiefly on the class of substances which serve their own tastes, so they exhibit a striking indifference to all other odours; but every one must have observed that the herbivorous animals have a power of perceiving animal effluvia, as is proved by their habits of mutual recognition, in which the nose plays a principal part. We must therefore be slow to interpret indifference as a want of perception.

The pointer, while traversing the turnip-field, tainted with the odour of decaying leaves, or when crossing the compost heap, where decomposing substances, both animal and vegetable, are commingled, appears insensible, but in truth, he is only indifferent to these: he anticipates the occurring of

a particular scent, and this obliterates all other impressions. We do not know a more beautiful instance of total concentration than is exhibited by the pointer on the hill side, or the stubble field; and what is the object which sustains his efforts? It is the passion for the chase, with all its uncertainties, surprises, and successes, deepened in the dog's blood by transmission from father to son for unnumbered generations. Were we to view it aright we might doubt whether we should more correctly say that the dog was serving the master, or that the master was serving the dog, and bearing the bag for him. Evidently it is a co-partnership for mutual profit; the biped, no less than the quadruped, is indulging the instincts which in prehistoric times sent his naked ancestors through the swamps and forests of the unreclaimed earth. This passion for sport shows that the modern *gentleman* to a large extent owes this title to his tailor; we see the rude propensities of primeval man still cropping up strong in our nobility and professional men, unsubdued by centuries of conventional restraint. It is the recoil of our animal nature against the trammels of an advanced, but too artificial style of life.

The great practical object of the sense of smell is, doubtless, in man as in other animals, to assist in the choice of food. In this it acts preliminary to the organ of taste; and there exists a natural sympathy between the two organs. Besides this practical employment of the sense, it affords to man a refined, and delicate, and not over-obtrusive enjoyment; silently, and perhaps unobserved, enabling him to stamp an additional character of sweetness upon what is lovely in form and colour; and, fortunately, the beautiful in scenery is generally allied with what pleases and gratifies this sense. The mountains of Switzerland we associate with the flavour which the sun exhales from her pine forests. The banks of Tweed's "silvery stream, glittering in the sunny beam," are ever in our minds seasoned with the odour of the whin blossom, among which, in boyhood, we searched for the

linnet's nest. A single puff of peat-reek will make the man of business, immured in his counting-house, stop his pen that he may muse on the seclusion of the Highland glen. Many persons find the suggestive powers of odours greatly superior to those even of vision; the reason may be, that whereas vision at once reveals its object, and in the act satisfies our intelligence, the sensation of scent is generally anticipative, the mind is for a time in a position of suspense, dwelling on the sensation, and busied predicating the cause; the impression thus becomes vivid and indelible. Thus every country, and every large city we visit, has its distinct savour, woven with its other wonders into the mind, and which, like a mysterious and invisible genius, hovers over it. The coal smoke of London fills the nostrils of the visitor, and never leaves them; the damp, greasy flavour of the narrow streets of Paris, the turfy smell of Holland, and the putrid effluvia of Constantinople, give a smack and character to each place which is not easily forgotten.

There is only one other remark occurring to us in reference to the organ of smell: it may be thought unworthy of admission into a scientific and philosophical treatise, but let those who judge so explain its cause. How does it arise that the nose, of all the organs of the body, excites in our minds the sense of the ludicrous? Any imperfection or malformation, or any misfortune befalling it, is immediately laid hold of as a subject of merriment. The eyes are the constant objects of panegyric; the mouth, the lips, are almost equal favourites: the praises of the nose have not yet been sung, except in Hudibrastic measure. Is it the prominence and pretension of its station that draws this ridicule upon it? The ear lurks among the folds of the hair, listening in secret, and escapes comment; but the organ of smell, whose office is considered by many as of a *quis quis* nature, stands boldly forward in the van of the organs of sense, although of all of them it is the most helpless and vulnerable. Does this circumstance draw upon it the wit

with which it is universally assailed? If it is straight and commanding we accord a seeming homage to it, so long as it escapes accidents; but this is a felicity rare and impossible. Accidents will occur; and no sooner does an unfortunate hit come, than it is immediately made apparent how feeble a hold it possesses of our reverence. The whole philosophy of the ludicrous is involved in difficulty, which it requires the metaphysician to unravel. That Mephistophiles should chuckle at the mishaps of mortals, and at the grotesque and awkward attitudes in which they are occasionally thrown, is not unnatural; but that the best and gravest of men should enjoy a joke at the innocent defects of humanity is not easily explained. Does it arise from a feeling of the incongruous, and an apprehension that the spirit of man is but unworthily housed in flesh,—the cogitative philosopher cribbed up in the body, and struggling against the disadvantages of his situation? This may help to account for it; but as a Kantist would say, we *could* not laugh unless we had within us a laughing nature; and *why*, according to the law of our being, we should be destined to laugh, and what the hidden link which so closely connects this peculiar member of the body with the humorous faculty, is an enigma.

CHAPTER XXIII.

TOUCH.

HOW MANY SENSES ARE THERE?—DIFFERENT MODES OF CLASSIFICATION—DIFFICULTIES WITH REGARD TO THE SENSATIONS OF TOUCH—TASTE AND SMELL FREQUENTLY CONFOUNDED—SENSATIONS INFINITE IN NUMBER—SYMPATHY BETWEEN THE BODY AND THE MIND—VITAL ENERGY—PHYSICAL DEPRESSION—PHILOSOPHY OF PAIN—CONTROL OVER NERVOUS ENERGY.

HOW many senses does man possess? The question is a difficult one to answer if we determine to be strictly scientific. Are we to settle it on physiological grounds by pointing to the external organs of sense, or are we to make the distinction rest on the nature of the external agencies, which act on the nerves, and through these on the mind? or, third, are we to discover psychological distinctions, and, grouping sensations which are in some measure correspondent, endeavour to settle the divisions and subdivisions under which they may be ranged. Connected with each of these methods there will be found certain difficulties which prevent them being regarded as altogether unobjectionable. For, first, as regards the physiological method: though we know with some certainty the position, and in part also the course of the nerves of special sense and of general sensibility, we cannot speak with much certainty of the portion of the brain in which their fibres are ultimately merged; and even if we knew this, we have still to discover whether there be any peculiarities in the histological constitution of the several cerebral lobes on which our different senses are dependent, and which may possibly help to account for the peculiarities in the sensations evolved.

Then, again, when we attempt to classify the senses by

a reference to the nature of the external agencies by which we are affected, we discover very soon that though the nerves of general sensibility raise in us a vast variety of very different sensations, depending more or less on the nature of the external objects brought into contact with them, these sensations depend still more on the particular way in which the external objects are made to act. It is evident that the mind never, by the simple sense of touch, perceives the external object. The impulse is transmitted through a lengthened cord to the brain, where the sensation is localized. And what is the sensation of pure touch? A something quite indescribable, and which in itself as a sensation, and without the impression of form and other supplementary adjuncts, can give us no knowledge of the nature of the external object.

The sensations of touch depend on the nervous action excited, and this again, to a large extent, depends on the manner in which the external impulse, whether natural or artificial, is applied. And the same principle holds true with regard to hearing and sight; for tone and colour depend on the rapidity of the impulses made on the nerves. There is, however, this important distinction between the nervous apparatus appropriated to general sensibility and that appropriated to the production of our special sensations, that while the former excite a class of sensations which vary almost endlessly, according to the ways in which the impulses are given, the nerves of special sense, by whatever means they may be excited, render only their own very peculiar and much more limited range of sensations. Thus the sensations of red, yellow, blue, and of all the intermediate colours, are due to specific differences in the rapidity of the vibrations of the ethereal medium, and the sensation of pure light to the joint action of these different vibrations blended in certain proportions. But the peculiarity of the sense of vision is, that whatever may be the stimulant, and however it may be applied, no other sensation is ever obtained than a sensation

of light, in some one or other of its modifications. If we press the back part of the ball of the closed eye with the knuckle, we perceive a prismatic circle, as if projected on the opposite side. If we receive a stroke on the eye, we perceive, as it were, sparks of fire darting from the part. When we have been in the dark for some time, if we roll the eyeballs suddenly from side to side, we become conscious of flashing light. If we continue to move them more slowly, we have the impression that space is suffused with a more or less powerful illumination, or with extended patterns of particular sizes and colours.

In the same way as the pitch of musical notes, from the lowest bass up to the highest treble, depends on the rapidity of the vibrations entering the ear, so the auditory nerve, in whatever way it may be acted on—by a stroke, by laceration, by the friction of the arterial blood—transmits to the mind nothing but varieties of sound.

It would seem also that experiments on the nerves of taste and smell furnish corresponding results, though this is not so easily established, owing to the mixing of different nerve fibres in the organs of these senses, and also from these peculiar sensations being much more vague than those of light and sound, and therefore less easily discriminated.

All difficulties considered, then, we see no advantage in denying the validity of the ancient doctrine, that whatever inlets to knowledge insects and other animals may possess, man is endowed with his five senses; namely, with vision, hearing, taste, smell, and lastly, touch, or general sensibility.

With regard alone to the last of these the case is peculiar. We shall, therefore, make a few remarks on the office and functions of this sense. The sensations of heat and cold, of simple touch, of tickling, of pain, of pressure, of muscular fatigue, and many others, are so different in their character, and in the causes exciting them, that some sticklers have considered this sense of general sensibility to be not amenable to the proprieties of scientific classification; and we must

all admit that the purposes of language require that we should subdivide the indications usually slumped under the generic name of touch, or general sensibility, for thus only can we convey information either regarding our sensations, or regarding the external causes which excite them; but this attempt is sometimes not without its difficulties, for he is a skilful pathologist who can assign an unerring cause for all the sensations and pains which normally, or abnormally arise in the human frame. Thus, first, we find that there are many sensations identical as mental phenomena, which are excited in the nerves of general sensibility by entirely different means. And, again, there are sensations so different as not to admit of being either compared or contrasted, which are excited in the same nerves by the same cause, only differently applied. The application of a blister, for instance, produces in succession feelings of warmth, comfort, scalding, pain, and drowsiness. In the same way the effect produced in the mouth by pungent food is often mistaken for an undue amount of caloric in the food. As a familiar illustration, the school-boy in handling the strap as an object of curiosity is conscious of the sense of touch proper; but when the same instrument is sharply applied to the finger ends, the sudden contortions of the urchin show that a very different set of sensations is excited. We shall indeed find that most of the sensations due to the nerves of general sensibility may be made to pass either suddenly or gradually into sensations of a totally different character; were it not so they would be of comparatively little service. Touch is produced by the gentle pressure of any body, solid, fluid, or aeriform, on the skin; by an increase of pressure, the sense of touch passes into a sense of pain. A light touch, or a rapid succession of touches, produces a sense of tickling; a sudden, sharp application of a solid body produces heat. Tickling sometimes produces a sense of cold, thus the creeping of an insect over the skin causes a cold, shivering

sensation. The process of tickling, continued, ceases to be tickling, and becomes touch. Touch again, when long continued, ceases to be touch ; thus the skin loses its consciousness of the presence of the clothes upon the surface of the body ; and in like manner, if we hold a hard body in the hand without motion, we cease to perceive its form, or even to be conscious of its presence, till, by a renewed motion of the fingers, we excite fresh sensations. When the two hands are plunged into the same basin of water, we may, owing to a difference in their previous conditions, experience in the one the sensation of warmth, and in the other that of cold. These instances may instruct us in the nature of this sense, and convince us that the sensations of touch are subjective ; that they are relative, or matters of degree ; and, lastly, that though they are real, as states of being, yet they are, in themselves, unmeaning, and therefore cannot be described, except in the most vague and indefinite manner ; as by saying, that pain is painful, that cold is unpleasant, that tickling makes us laugh, and so forth. The same is true with regard to those other sensations which, because they are much more specific in their nature, are said to belong to the *special senses.* Nothing can be conceived more dissimilar and distinctive than the sensations of colour, sound, and taste, and yet we cannot tell wherein the distinctions lie ; the reason is, that these sensations have neither length, breadth, nor thickness, nor anything which in its nature is intelligible to us, but are mere subjective affections or feelings. We only learn to interpret them, that is to say, to attach a sort of practical meaning to them, from finding them pretty constantly connected with the same set of external circumstances and relationships.

All laborious attempts to classify rigidly and scientifically the above, and the thousand other fleeting and intangible sensations of which man is the subject, are equally vain and impracticable ; for what is man, physically considered ? He is a warm, pulsating organism, in which every part is

in a condition of constant flux and change. Each part is endowed with its distinctive life and feeling; and, when suffering, each part suffers in its own way. A pain in the liver differs from a pain in the heart, or the stomach, or the kidneys; the bones ache forth their peculiar griefs, and the head has its own sufferings to endure.

A brief reflection on man's compound nature will convince us of the frequent contests which must arise—the human mind, with its aspirations, and passions, and susceptibilities, and the animal organism, with its ebbs and flows, its recurring cravings, and its many irregular movements. We can see at a glance how far man's happiness, his goodness, his evil, his usefulness, his uselessness are dependent on the conditions of the bundle of forces of which his physical being consists. At one time the connection of mind with matter seems one of a purely penal character; at another time, fortunately, we are enabled to reject this idea, and to rejoice in finding that the body is capable of acting as an animating and sustaining principle. It is, in fact, the war-horse which carries us through the battle of life; and, feeling confidence in the strength of our animal companion, we are enabled to laugh at danger, and even to court a closer contact with it.

If the body were a mere mass of matter, a thing dead and passive, it could only serve as a prison for the mind; very different from this is its function. In its healthy or normal condition we find it yielding not only help, but also innumerable gratifications; imbued with its own peculiar energies, and with those finer vibrations which pervade the physical machine, these rise up and fill the mind with an indistinct but pleasurable music, such as is heard poured forth from a thousand throats, overhead and around, in the time of spring.

Such a full and constant health were perhaps, however, not for our good. Look we then to the other side. There is a state directly the reverse of the one described, when the body reminds us that it is composed but of earthly particles, and that the band which binds them together must, some day,

be loosened—that it is loosening even now. We speak of a state of not unfrequent occurrence, when there is not only no superabundance of life and strength, but when all is eminently stale, flat, and unprofitable—the skin is dry, the eye is lustreless, life flows in a sluggish current, and fain would we purchase a release by retiring into temporary unconsciousness. Some, when in this condition, will go to buffets with themselves, and with all the world besides; others will withdraw to a corner; they cannot face society—no spare vitality have they for the amiable nothings of social intercourse; ordinary business is only less insufferable; submission and silence are the sole available virtues; and to fight on, Sisyphus-like, with the necessary duties, pushing them uphill as best we can. Such conditions of the physique are more or less known to all—to the sanguine in temperament, no less than to the atrabilious and melancholic. With many, alas! they are habitual; and life is with such a daily burden and struggle, as was expressed, we think, by Fontanelle, when dying, *Je trouve une grande difficulté à être.* Life seems as if given to such men for no other purpose than that they may daily learn to die.

A prominent distinction between touch and the other senses may be noted. While each of the other senses is exercised by means of an organ admitting the impressions at only one point, the sense of touch is extended over the whole body. There would evidently be no advantage in the whole body being an eye or an ear, or possessing the sense of smelling or taste; on the contrary, there would be evident inconvenience in any such arrangement. It is sufficient that light and sound reach the sensorium from any one point, it being a matter of comparative indifference where the organs of these senses are placed, provided only they occupy a free and commanding station; and this advantage has been admirably secured to all animals, but especially to man, whose head is carried erect. The case is very different with regard to the sense of touch. This sense is intended to

advertise of external bodies coming in contact with the organic frame-work, and its organ is therefore spread over the whole surface of the body.

The organs of sight, hearing, taste, and smell exhibit in their construction this simple principle—that the terminations of the nerves are expanded over the respective organs, and so exposed that the external impressions may be most advantageously received on them. It is exactly the same with regard to the sense of touch. The nerves of common sensation, while they are distributed through nearly every part of the body, are most elaborately diffused over the surface of the skin, which may, therefore, in strict consistency be called the *organ of touch.*

In a state of health very little sensation is transmitted from the deeper parts to the sensorium. It is a well-known axiom, that a healthy man is not merely free from pain, but he is not even conscious of his health: experimentally he neither knows of his possessing heart, liver, lungs, or any other internal organ. The criterion of perfect soundness in these parts is an entire absence of feeling. This leads us to a principle of curious interest. Our less intellectual senses, we shall find, are given us for definite purposes, and they lie mute till a cause occurs for their speaking out. Thus the deeper parts of the body possess inferior sensibility to external impression. In surgical operations the pain is felt principally while the knife is passing through the skin: when the bones, joints, and the membranes which cover them, are exposed, they may be cut, pricked, or even burned, without the patient suffering pain. Mark, however, an exception to this rule, the advantage of which is very apparent. Let any disease arise in these internal parts of the body, a sensibility formerly dormant is immediately awakened, giving notice of danger, and calling aloud for caution and a remedy. Nay, we may mark a still nicer distinction: we find that the different parts of the bodily frame possess sensibilities special to themselves, and which

are excited only by injuries of the peculiar kind to which these parts are naturally liable. Thus, the tendons may be burned, or cut through by the knife, without exciting the slightest pain ; should they, however, receive a twist or strain, to which from their office they are peculiarly exposed, they become immediately the seat of severe suffering. The bones and cartilages, again, are insensible to pricking or cutting, but are sensible to concussion ; and each part, in like manner, is guarded, not by a general, but by a special sensibility, which serves to announce danger and to protect the part from the peculiar injury to which it is exposed.

In this we see very clearly the principal use and object of pain, viz. to advertise of danger ; and, as a general rule, it will be found that this importunate and disagreeable remembrancer is not more clamorous than is required.

Before passing from the internal parts to the external, we must allude to the sense of muscular motion which Sir Chas. Bell justly observes is indispensable to the due exercise of touch and motion. It is evident that, by our general sensibility, we are kept conscious of the position of our limbs, and of the extent of our muscular action ; and without this consciousness we would not have the means of regulating the out-putting of nervous power, and keeping our muscles properly in hand. We would not know the position which our limbs for the time occupy ; we would therefore be unable to balance our bodies, or to direct our legs and arms. A definite amount of nervous energy is required for each muscular movement, and it is essential that we possess the means of controlling the amount put forth, otherwise our movements become irregular and spasmodic. If we miscalculate, or are deceived in the amount required, as is sometimes the case, the nervous equilibrium is upset, and we receive a shock not unlike that of electricity. The effect is much the same whether we under or over-estimate the force required. Thus, in coming down a stair, if there occurs a step more, or a step less, than we anticipate, the nervous shock is nearly

equally severe. "When we consider all these facts," says Sir Charles Bell, in his Treatise on the Hand, "we can no longer doubt that the sensibilities of the living frame are appropriate endowments, not qualities necessarily arising from life; we perceive no instance of pain being bestowed as a source of suffering or punishment purely, or without finding it over-balanced by great and essential advantages."

CHAPTER XXIV.

TOUCH (*Continued*).

THE SKIN—ITS SENSITIVE PAPILLÆ—ITS GLANDS—LAW OF DECREASING SENSIBILITY—ITS DISCRIMINATING POWER AT DIFFERENT PARTS—DISTINCTIONS IN SENSATIONS INTERPRETED BY EXPERIENCE—MISINTERPRETED—MODIFIED BY ATTENTION—PAIN MODIFIED BY RESOLUTION—IDEAL PAINS—PAINS FROM MORBID STATE OF THE NERVOUS SYSTEM—NERVOUS EFFECTS OF ANIMAL MAGNETISM—SPIRITUALISM—CHLOROFORM—TICKLING—THE DROP—HOMŒOPATHY—REFLECTIONS ON THE NERVOUS SENSIBILITY—THE VELOCITY OF THE TRANSMISSION OF SENSATION AND VOLITION CALCULATED—THE BRAIN PROVED TO BE THE SENSORIUM—IS IT THE PERCIPIENT PRINCIPLE?—A MORAL REFLECTION.

THE skin, possessing the most nice and discriminating perception of touch, demands our particular consideration. The skin, which envelops the whole body, consists of two layers—the cutis, dermis, or true skin, which lies beneath, and the cuticle, epidermis, or scarf skin, which covers it. The epidermis is sometimes described as consisting of two layers—the upper or scarf-skin, and the under, which is soft, and is commonly called the *rete mucosum*, or *rete malpighii.* In this last is found the pigment globules which mark the colour of the Negro race. The cutis, or true skin, lying beneath this, is vascular, being permeated by the finest capillary blood-vessels, and the terminations of the nervous filaments. Viewed microscopically, it is found to consist of fibres and laminæ densely woven together. The epidermis, which is not vascular, and which is a dead or insensible covering, protects the true skin from the air and external injury. From the friction to which it is exposed it is continually scaling off, and is as constantly renewed by the vascular surface below. It is through the intervention of the cuticle that the modified

impressions of touch from external objects are conveyed to the extremities of the nerves lying beneath. The existence, close under the surface, of these nervous terminations is indicated by the papillæ which more or less ridge the skin at all points, but which are most numerous in the palms of the hands and at the points of the fingers and toes. If the points of the fingers be examined, we observe minute circular furrows running in close parallel lines. Each of these elevated lines contains one, but generally two, rows of papillæ, which lie so close as to appear an uninterrupted smooth line. These papillæ are frequently the sheaths in which the extremities of the sentient nerves are lodged. In some of the papillæ—in the fingers, toes, and some other parts—Wagner and Meissner have discovered minute bodies, called touch corpuscles; these are oval bodies about $\frac{1}{300}$ of an inch in diameter. Within these is a soft core, and without they consist of a capsule of indurated connective substance. Round these bodies one, two, or more nerve fibres are usually twined spirally till they reach the top, when they seem to pass into the soft core. These are believed to be the parts possessing the greatest sensibility.

In the coloured races of mankind the cells of the epidermis, and especially of the lower layer of it, are filled with minute black pigment granules, many of which lie loose among them. The epidermis in the Negro family is peculiarly thick, a circumstance which was sometimes held by the abettors of slavery as sufficient to justify the exclusion of that race from a right to the privileges accorded to the rest of the human family. The skin, besides these sensitive papillæ, possesses a sudatory apparatus of surprising delicacy. This consists of amazingly minute glands situated in the cutis, which secrete perspiration, and discharge it through fine tubes which open on the surface of the cuticle. These pores are more or less dense in different parts of the skin; but supposing they average 2800 to the inch, and that there are 2500 inches, or about seventeen square feet, of

superficial area in a man of moderate size, it is evident that he will have not less than seven millions of these orifices, and their corresponding glands, spread over the surface. The perspiratory fluid consists of water, holding a minute quantity of animal and saline matter in solution, besides free nitrogen and carbonic acid. By thus removing carbonic acid from the blood, the skin next to the lungs is the most important excretory organ. The skin is also densely furnished with another set of pores, through which is discharged a limpid oil for softening the surface and checking the redundant perspiration. These are connected with the sebaceous glands, in which this unctuous matter is formed, and which lie sunk in the cutis.

The roughness of the skin at the finger-ends, caused by the ridges of papillæ, gives manifest advantages to it as an organ of touch. It causes just that degree of adhesion or tenacity which is most important for a critical examination of an object. The elevation of the ridges also brings each row of nerves successively over the surface of the object examined. We may here observe that while the separate presentation of the nervous ends is a condition essential to the proper exercise of the sense of touch and sight, which require a perception of the position, shape, and surface of the objects examined, this is not the case with the organs of hearing, taste, and smell, where the transmission of the specific sensation is all that is required, and where the perception of shape is inconsistent with the requirements of these senses; we accordingly find that the nerves of these senses, at least in the organs of hearing and smell, are exposed in a totally different way.

While the passage of the ridges of papillæ at the finger-ends over the object examined is an arrangement securing the nicest exercise of the discriminating faculty of touch, it also produces and keeps up the greatest amount of nervous action. It is a peculiarity common to all the nerves of sense, that any external impression, if long con-

tinued, gradually loses its vivacity; and it is found that motion, or friction, or change of position, is needful to renew the sensation. Thus, when we gaze fixedly on a single point, the eye becomes fatigued, and the object becomes indistinct. The movement of the eye, however, refreshes the retina, and its vivacity is quickly restored. For the same reason, in the exercise of taste, the food must be rubbed over the tongue and palate. In smell, the volatile particles when first drawn through the organ produce the fullest effect, but when we continue for any length of time exposed to an atmosphere loaded with a peculiar flavour, we gradually become insensible to its existence. The same law applies to the nerves of touch. We have remarked in the preceding chapter, that if we press the hand steadily on any body, after a certain time it loses the power of discriminating the nature of the surface pressed, and we cannot tell whether it be rough or smooth, round or square, until we shift the hand, and by friction over it stir up the dormant energy of the nervous extremities. Keeping these facts in view, we shall more fully admire the papillary ridges at the finger-ends: the act of passing them over the surface of the object examined creates just that gentle friction and that successive pressure, and relief from it, which are needed.

The structure of the hand as the principal organ of touch, its pliability, sensitiveness, and strength, as fitting it for being the principal instrument for executing the designs of the mind, has been already alluded to; and when we consider that we invariably seek to verify the somewhat vague report of touch, regarding the form of objects, by the motion of the hand and fingers over them, and their solidity by the pressure of the fingers against them, we shall be able to appreciate the admirable fitness and ability of this organ.

The extent to which the skin is supplied with nerves, and possesses sensibility, is evidenced by the fact that there is no part of it at which we can insert a needle-point without inflicting pain. The discriminating power possessed

by it, however, varies at different parts, and this is generally said to depend on the number of nervous terminations with which it is supplied, and probably also upon the extent of isolation of the nervous filaments.

Professor Weber has given a scale, marking the discriminating power of the skin at different parts. He fixed small pieces of cork on the points of a pair of compasses, and by setting the ends more or less apart, and pressing them upon the skin, he found that at some parts the two points were indistinguishable, and appeared as if fused into one; by opening the compasses gradually, he ascertained the distance at which the pressure of the two points could be distinguished; and this varied exceedingly at different parts of the body. The following are a few of the results arranged in the order of susceptibility, and our readers may test their general accuracy by applying the compasses, not to their own bodies, but to that of their neighbours while their eyes are shut:—

Impressions on the tip of the tongue were distinguished at a distance of . . .	½ a line.
At the end of third finger . .	1
End of second finger .	2
Palm of the hand . .	5
Cheek . . .	5
Back of the hand . .	14
Back of the neck .	30
Middle of the back . .	30
Arm . . .	30

It is by experience alone, and not by instinct or intuition, that we acquire the full use of our senses, and become able to refer our sensations of touch to the part of the skin affected. An infant, when subjected to a surgical operation, screams and convulsively moves its limbs, but makes no peculiar effort to withdraw the part operated on. Another instance, already given, we may again refer to as showing the effect of experience. When the skin is removed from the forehead in the

surgical operation of forming a new nose, the touching of the new member is always referred to the forehead, and it is only after the adhesion on its new situs has been thoroughly established, and the band, with the nerves which connected it with its old position, has been cut, that the seat of the sensations is correctly indicated by it.

The experiment with which young people amuse themselves illustrates the fact that our simple sensations may at any time deceive us, and that every act of perception is founded on experience, and requires collateral proof to verify it. If the fingers be crossed, and a pea be rubbed between them while the eyes are kept shut, we have the very distinct sensation of there being two objects between the fingers. The explanation is, that the nerves on the remote sides of the fingers, in their natural position, cannot receive two impressions simultaneously, except from the pressure of two objects; in the present instance, however, they are in an unnatural position, and the nerves of the remote sides of the fingers being brought to bear upon the one small object, we are by this led to judge according to former experience, that as we have two distinct sensations in different and remote parts of the organ of touch, there must be two distinct objects exciting them.

The influence of the mind and of attention, in increasing or subduing sensations, is well known. While the thinking principle is thoroughly engrossed with any one object, the corporeal system becomes comparatively insensible to external impressions.

The mind which is incapable of conceiving a great idea can never have power to stand in defence of a good cause. The martyr, borne above sensuous impressions, is not only able to endure tortures when they come, but in great part to subdue them. His eye sees heaven open, and the stones which fly around, though they may bruise the body, cannot interrupt the visions revealed to his upward gaze. The pinching and cutting of the flesh only add energy to the

death-song of the American Indian—the slave under the lash is sustained by the indignant sense of his wrongs. It is the man alone who is without an object, or whose object is mere self-indulgence, that stands unsteeled: without fortitude or virtue, he not only feels to the full all real pains inflicted, he suffers also imaginary ones; for, while we have numerous proofs that agony may be conquered by resolution, the contrary fact is equally well established, that a state of nervous apprehension and timidity may almost, to any extent, aggravate the amount of physical suffering.

There is a class of sensations which assume an objective character. These we cannot call purely ideal, seeing they arise from a morbid or diseased state of the brain or nervous system, the effect of which, according to circumstances, may be either to unsettle the judgment, to excite grotesque and ridiculous apprehensions, or to assume the form of sense perceptions, and produce the impression of spectral illusions and phantasms. The victim of these is sometimes unconscious of the imaginary nature of the appearances: they are before him, and he must believe in them; at other times he is perfectly aware of their purely subjective character, and yet is unable to shake them off, or by all his powers of mind to diminish their illusory effect.

Before quitting this subject, we may allude to a happier class of sensations, namely, to those bright images which many persons in health can call up in the dark, and which have all the vividness of reality. With many children this is a favourite amusement. Shutting their eyes, they will recount to one another, with the liveliest enthusiasm, the sights they conjure up: the grand in scenery, the evolutions of soldiers, and such like, pass in panoramic and pantomimic review before their mind's eye, according to the bent of their imagination at the time. We doubt not but these images, though originating in the mind, yet owe their vivacity to an action produced on the retina, or in that part of the cerebral organ connected with it, and that the mind and the retina act and

react till the work of imagination becomes heightened into a condition in which all the effects of an external physical reality are produced.

Another peculiar state of the nervous system it would be wrong to omit, namely, that induced by what has, perhaps unfortunately, been called animal magnetism. It cannot be doubted that a very remarkable and peculiar state of mental and nervous action may be induced, in which the mind of the patient becomes nearly passive, and in which the senses can be either singly brought into a state of unnatural susceptibility, or be depressed into partial or entire abeyance.

The impression made on those who witness the experiment is, that the subject of it is thrown into a state in some respects analogous to sleep-walking—in which an important part of the mental as well as the bodily organism is rendered inactive. The peculiar effect, it would seem, is induced principally by a successful process of fatiguing at once the attention and an important part of the brain. An object is presented which, by its natural inanity and monotony, is capable of gradually leading the mind off its active idea-generating duties into the land of trance and nothingness. When the mind is thus drawn from the *many* to the *one*, and from the *one* to the *nothing*, the principle of calculation, of comparison, of self-control, is lost, and the emotional powers of the mind, and the motor apparatus of the brain, are exhibited free to act under the influences of external suggestion. When these are brought to bear, the man emerges into consciousness as a child; his delights and his horrors are felt in infantine excess, such as we have them during sleep. Altogether, the state induced is well worthy of being studied by the physiologist and metaphysician. It is a pity that the very marvellousness of the phenomena exhibited should have thrown the subject so much into the hands of travelling charlatans, and thus have disgusted and alienated philosophers from a cordial and scientific study of it.

Philosophy has been somewhat disturbed in our day by

the appearance of phenomena alleged to be either purely spiritual manifestations, or to be the result of peculiar cerebral power, and which is capable, it is alleged, of acting external to the organism in various ways, physical and mental. These phenomena are so at variance with all we know of physical and mental law, that till we have witnessed them under circumstances which we judge sufficient to exclude all possibility of fraud, we must reluctantly remain unconvinced, even by the assertions of the most able and sagacious observers. We are justified in taking up this position because it is evident that the candid supporters of spiritualism confess that they see ever and anon evidence of fraud peeping out and throwing suspicion over the subject. Although from the uncertain and capricious nature of the phenomena there is much difficulty in prosecuting a regular process of proof, yet we are convinced that ere many years elapse this most wonderful and, if true, most important subject will either be established or be banished entirely from the mind of all sensible men.

The effects of anæsthetical agents, and their application in surgical cases, is a new instance, and one of the most striking we possess, of a chemical agent affecting nervous sensibility; its peculiarity is, that while it suspends all action of the sentient nerves, and also those of voluntary motion, it leaves, in great measure, intact the energy of the sympathetic system and the organs of animal life. The discovery of such an agent must be ranked as one of the most fortunate which medical science has achieved; and following upon the discovery, we may add, that the immediate and fearless application of it reflects no less renown on the practitioner who first availed himself of it, and brought it into such immediate and general use.

The sensation of tickling differs essentially from that of touch or a sense of pain, and yet it is produced by touch, and may become intensely agonizing. It is a nervous excitement, and may be either agreeable or the reverse, according

to the idiosyncrasy of the individual. It is sometimes submitted to on the soles of the feet, as a restorative after fatigue; but in every instance, where it is forcibly inflicted, it is greatly dreaded, and produces muscular convulsions and hysterical effects, which, if long continued, may completely exhaust the nervous energy and produce death. The annals of crime prove its having been resorted to by wretches who wished to kill in a way which would leave no visible mark on the body of their victim. The touch of a feather, or the contact of the small feet of a fly moving on the cuticle, or any cause equally slight, is the most effectual excitant, and neither man nor the lower animals have fortitude to submit to it; in this sensation we may say the magnitude of the effect is in inverse proportion to the magnitude of the cause exciting it.

Being produced by slight but rapid touches, the peculiar sensation is evidently rather the effect of the movement of the nervous current, through single or isolated nerve fibres, than the perception of an external object. It is necessary for the effect, not so much that the body exciting it should move rapidly, as that it should make its impression on the skin merely, and not go deeper, and that the contact should be confined to one point at a time. So soon as the sense of touch proper commences, the sense of tickling ceases, and this takes place so soon either as the pressure is increased or any considerable number of contiguous nervous papillæ are simultaneously affected. It is a consciousness of the uncertain nature of the exciting cause—a cause which we can neither recognize as an object of touch, nor define, nor oppose by muscular pressure—that doubtless aggravates the peculiar nervous effect.

Of a kind somewhat analogous to tickling was the dreadful punishment of the drop, where the victim was bound hand and foot, and a drop of water, at slow intervals, was made to fall on the crown of the head. Madness and death were said to be the result of this refinement in torture. This was

an instance of being killed by sensation; but the effects were aggravated, be it remarked, by the consciousness that it was inflicted for cruel ends, and that it was compulsory, and could not be escaped from. Were it not for this conviction the sensation might not only be innocent in its effects, but probably agreeable; for it is a practice very common in the East for mothers, when obliged to leave their children, to direct a drop, or small run of water, over the head of their infant, and the sensation produced rarely fails to soothe it into a profound sleep.

While considering the subject of causes so slight, producing, through the nerves, such effects, what shall we say of homœopathy? The first and most natural impression is, that it savours far too strongly of German idealism to be for a moment admitted. We are not here to inquire whether this method of medical practice be a good one, but merely to consider whether or not it is a system having any possibility of truth in it. Now, to stay the laugh of unthinking incredulity, we may allude to the effects, sometimes fatal, produced by the slight causes above enumerated. We may allude also to the effects produced on the frame by mental emotion, or to the effects produced on the organs of sight and hearing by the impact of impalpable molecules. Most people know, also, instances, where the taste of an egg, however disguised, or the smell of cheese or of musk, have produced sickness or convulsions. The smell of a particular flower or fruit sometimes brings on serious illness, and realizes in its victim the poet's fancy of being "killed by a rose in aromatic pain."

When the plague, or any other fatal epidemic, is ravaging a country, and cutting down its thousands, the victims fall smitten by a specific poison; and yet when is chemistry able to detect the presence of the fatal virus in the air, or earth, or water which produced such desolating results? When we admit the existence of such things, we may be more readily inclined to receive as possible the pretensions of the homœopathist. We know nothing of the nature of the elements at work

within us, in cases such as the above, nor the nature of the relation between the energy existing in the infinitesimal specific and that existing in our nervous system. When the allopathist gives a few grains of ipecacuanha, or opium, or calomel, or when the distiller throws a gallon of yeast into the many thousand gallons of wort, neither of these parties imagines that the weight of the agent has much to do with the magnitude of the effect produced; on the contrary, they know that a concealed energy in the agent will act upon an energy in the subject of their treatment; that a little leaven leaveneth the whole lump; that a small helm guideth the large ship; that energy may be concealed, pent up, and then unlocked by a little key. Health, physicians say, is vital power properly directed; disease is the same power working in a suicidal direction. The homœopathist may, to gross eyes, appear to proceed on grounds purely metaphysical, when he administers his trillionth part of a grain, and *indicates* the specific in the body as a sign or whisper, to influence the spiritual principle which regulates our being. It is held by him sufficient that the sign is the right sign, the word whispered the right word; there is no need that the sign be blazoned in gigantic characters, or that the word be uttered by the blast of a trumpet. As the keeper in an asylum rules by a look or a gesture, indicating peace or authority better than by a blow; or as a person off his course may be set right by a finger-post; or as a whale may be drawn from his destructive purpose by an empty tub; or a runaway horse be brought up, not by force opposed to force, on the allopathic principle, but by the guidance of a rein turning him unperceived out of his course into a *cul de sac;* so the disciple of Hahnemann uses craft. He does not take the bull by the horns, but by the waft of a handkerchief he turns him aside, and the misdirected force is made to work in a safer channel. In Holland, the apothecary used, not many years back, to send round his ponderous phials in a wheelbarrow; the German, on the contrary, applies himself to the spiritualities of our physical being.

These, no doubt, may be considered fanciful illustrations: the theory has now for many years been under trial among us, and, having received the support of many men of talent, it asks and will receive from the public a dispassionate verdict; if it has truth in it, it will be found, many years hence, standing its ground in spite of that severity of judgment which has been applied to it, as to all deviations from orthodox medical practice.

The study of such phenomena as we have alluded to seems to illustrate the mysterious nature of the connection between the physical and the sentient principles of our being; but, to have justice done to it, it would require lengthened and minute study. The mere consideration of some of the phenomena alluded to may raise in the mind the questions, What is pleasure, and what is pain, or what are any of the other affections of sense? Are they in the mind, or are they in the body? Are they in the brain?

In a subject so beset with difficulty as sensation, we should rejoice when any really important point can be said to be established. We are glad, therefore, to know that one of the questions just asked has in recent times been set at rest. In chapter xviii. we referred to investigations begun by Professor Helmholtz, in 1850, and since then prosecuted by other able experimenters, with a view to ascertain the velocity of the transmission of nerve-action in dead and in living subjects. We may here state, that in man sensation has been proved to travel at the rate of about ninety-seven feet in a second. When the impulse was made on different parts of the body, the interval of time between the giving of the impulse and the perception of it, bore a constant relation to the length of the nerve fibres through which it had to travel before reaching the brain. These interesting experiments, conducted with great care and in various ways, seem, then, to have established the truth of what was long surmised (but which was disputed by some philosophers), that sensation is localized solely in the brain; and that there is no conscious sensibility in any other part of the body.

We cannot but regard it as highly important, both to the mental philosopher and to the physiologist, to know that a general surmise of this kind has been confirmed by the authority of experiment, and to know that the brain is the sole organ of the mind, not only in the exercise of thought and voluntary motion, but also in sensation.

It may be asked, Have we then grounds for supposing the brain to be the sentient principle? It is important to know that, quite apart from all arguments, founded on the incongruity of the laws of mind and the laws of physics, physiological experiments have gone to prove that this, the organ of sensation, only produces sensation when it is affected through impressions made in the legitimate way on the nerves. The experiments of Flourens and others led them to conclude that creatures operated on were not sensible of pain when the knife was removing successive slices of this all-important organ. As an illustration, if not also as an explanation, let us consider that a violin will produce no music by any direct action on the body of the instrument. Its vibrations must be excited by an action in the strings; neither will the brain act, it would seem, so as to produce sensation, except through the appropriate action of the nerves. And we may complete the parallel by saying, that neither the violin nor the brain are anything but physical instruments, in no instance are they percipient either of their own physical movements, or of the sensations which result,—perception can only exist in an intelligent principle.

In closing these chapters on general sensibility, it comes within the province of an author, dealing with the philosophy of the senses, to make this practical remark. While men and women who are destitute of emotion can neither have any great store of enjoyment within themselves, nor possess much attractiveness for their neighbours, yet it ought never to be forgotten that the senses are syrens which are ever ready to draw us upon the rocks. They therefore require to be held

firmly in hand. Any over-indulgence of man's emotional and sensational nature, even in religion, has its dangers, and tends, through the operation of laws of which we shall have to speak when we come to treat of nerve-function, to enfeeble both mind and body, and induce morbid cravings which may become the blemish or the ruin of manly life. The keeping of our sensational nature, therefore, wisely and discreetly within the bounds of moderate and healthy action, is one of man's highest and most important duties.

PART IV.

THE NERVOUS SYSTEM.

CHAPTER XXV.

THE NERVOUS SYSTEM.

THE SYMPATHETIC AND THE CEREBRO-SPINAL NERVES.

HAVING conducted our inquiries up to the point where impression is made on the nervous extremities spread over the organs of sense, we are naturally led, before going farther, to direct our attention to the nature of the nervous system and brain.

In all the higher orders of animals this law holds, that impressions from without, in order to be perceived must be transmitted to the brain—the common centre of sensation. This is effected through the medium of the nerves of sensation. We shall now, therefore, give as brief an account as possible of the nervous system.

The nerves consist of many millions of minute fibres or filaments, which are conveyed through the body generally in fasciculi, or bundles, and from these distributed with amazing minuteness to every part of the body. They are divided into two systems, distinct in their position, functions, and appearance. First, we have the cerebro-spinal, or nerves of *animal life;* second, the ganglionic or sympathetic system, called also the nerves of *organic life.* The former are all connected with the brain, either directly or through the medium of the spinal cord, and are the media of *sensation* and *voluntary motion.*

The sympathetic nerves, though they have numerous fibres of communication, are yet not so intimately connected with the cerebro-spinal system. They are distributed through all the organs contained in the trunk of the body, the heart, the

lungs, digestive canal, glands, etc. They afford nervous power to these organs, and are supposed to be essential to their growth and nourishment, or vegetative existence. The sympathetic nerves have numerous ganglia or knots occurring throughout, from whence they frequently receive the name of *ganglionic nerves*. This, to the sight, at once distinguishes them from the cerebro-spinal nerves. The sympathetic nerves are also distinguished by their general grey colour, while the colour of the cerebro-spinal is white. The trunks and chief branches of the cerebro-spinal nerves are often of considerable size. The sciatic nerve, for instance, is about the thickness of a quill; the sympathetic nerves, on the contrary, are exceedingly minute, the largest branch being no thicker than a stem of grass, and they are so finely distributed throughout the organs as to be very difficult to trace by dissection. The fibres of the sympathetic nerves vary in size from one-thousandth to one eight-thousandth of an inch in diameter.

The organs to which the sympathetic nerves are distributed, while in a healthy state, have but a vague sensibility. When, however, they are the seat of disease, these nerves, either by their own filaments—some of which are sent to the spinal cord—or by means of nervous fibres of sensation distributed among them, and connecting them with the brain and spinal cord, convey impressions of uneasiness or pain.

The sympathetic system of nerves seems to possess its nervous power to a certain extent independent of the cerebro-spinal system; and there can be no doubt that the ganglia act in this respect as detached or independent centres of nerve power; thus in some measure discharging the office, in the sympathetic system, that the brain and spinal cord discharge with reference to the cerebro-spinal system. In corroboration of this view, we call attention to the remarkable fact that such of the organs as have sympathetic nerves distributed through them possess involuntary motion, and have a power of maintaining their action after they are removed from the body. Thus, the heart beats, and the peristaltic motion of the

intestines continues, by virtue of the influence supplied by their nerves and ganglia, for a considerable time after all connection with the rest of the body is destroyed.

The peculiar characteristic of the organs connected with the sympathetic system of nerves is that their functions are performed involuntarily. A very evident advantage arises from this partial isolation and independence of the organic system. In the first place, their *sensibility* being indistinct, they perform their functions in silence, sending up few intimations to the sensorium, and thus not interfering unnecessarily with the higher mental operations. And, again, their action, though regular, being involuntary, lays no tax upon the intellectual principle; indeed, so independent and isolated are they, that the mind has no power of exerting any influence on them. Just as in a well-ordered establishment the kitchen and other offices are built apart from the mansion, or connected only by a narrow passage, so it is with the members of the organic system; they are to a considerable extent self-contained, and the charge of nutrition, digestion, respiration, and secretion, is handed over to them as subordinates, in order that the brain—the seat of sensation and reflection—may be undisturbed by the grosser operations of organic action. Were we disposed to indulge the fancy, we might without any stretch say that the organs contained in the trunk of the body are members of a distinct corporation, in which each follows his own trade and possesses an independent animal existence, by virtue of its ganglionic nerves living and moving as a separate being: there is much of this life and individuality about each one of these ganglia-supplied organs.

That the isolation of the sympathetic nerves is, however, only partial is proved by the fact already mentioned, that when there is disease, the organs transmit a distinct sense of pain to the sensorium. And, again, though by no act of volition can we control the motions and functions of the organs contained in the trunk of the body, yet, under the excitement of strong mental affections, their action is power-

fully disturbed. It is from this circumstance that the name of *sympathetic* has been applied to them, and that in all times, from Plato and Aristotle downwards, the strange position has held its ground, that the heart, the stomach, the bowels, the spleen, and the liver, are the seats of distinct passions and affections.

It has been established by experiment, that it is by means of the fibres connecting the sympathetic with the cerebro-spinal system that the nervous energy of the former is maintained in force, and restored when exhausted. Thus, by cutting the *nervus vagus*, a nerve issuing from the brain, the power of the stomach and lungs rapidly becomes exhausted, and ere long the organs entirely cease to act.

We need not dwell longer on the functions of the sympathetic nerves, as it is principally with the cerebral and spinal nerves we have to do.

The nerves of sensation and of voluntary motion are subdivided into two classes: those which issue direct from the brain, and which are called cerebral; and those which, though coming originally from the brain, emanate immediately from the spinal cord, and are thence called cerebro-spinal. Both these consist of very fine tubular fibres or threads, arranged in larger or smaller parallel fasciculi, invested by a membranous sheath called *neurilemma*. In following these bundles in their passage through the body, we might be led to suppose that they have frequent connections with each other, for branches are continually observed to pass from one sheath into another. More minute examination has however satisfied physiologists that the ultimate or primitive nerve fibres are never united, and, though many fibres run within the same sheath, that each holds its independent course from its root in the brain to its final termination; the apparent union of the branches being merely for the purpose of more ready distribution to the parts of the body to which they are destined.

The size of these primitive fibres is from $\frac{1}{3700}$ to $\frac{1}{1840}$ of

an inch in diameter. In structure they consist of an external tubular portion, called the neurilemma, and an internal substance which forms a smooth homogeneous thread that appears to be filled with a gelatinous consistent humour, which part is called the *axis-cylinder*, or *white substance of Schwann.* The greater part of the substance of the brain, the spinal marrow, and the other nerves, have alike this fibrous structure, and seem to consist of cylinders containing this gelatinous fluid. On pressing these fibres they have a tendency to assume a beaded appearance. The cause of this must arise from the peculiar composition of the nervous substance—probably from the admixture of oily or fatty matter which it contains. These fibres belonging to the brain or spinal cord can be partially traced from their terminations on the different parts of the body either directly to the brain or to the spinal cord ; and though we cannot follow them through the line of the spinal cord into the brain, yet an examination of the spinal cord shows us that it consists of similar tubular nerves and fibres which run parallel, but do not incorporate. We have, moreover, evidence that such is the case from the impressions of sensation transmitted to the brain by each sensitive nerve.

Those nerves which issue from the spinal cord are, as we have remarked, called cerebro-spinal. There are thirty-one pairs of such nerves. They issue in a nearly continuous line on either side of the vertebral column, and within about half an inch of the place of their emergence they are collected into fasciculi for the purpose of distribution throughout the body. (See Fig. 43).

We have now to attend to a distinction in the function of these nerves, the discovery of which, next to that of the circulation of the blood, is, we conceive, the greatest which the science of physiology has achieved. Sir Charles Bell first conceived the idea that the posterior roots of the spinal nerves were nerves of sensation, and that the anterior were nerves of motion. He promulgated this view in a treatise,

dated 1811, entitled, "An Idea of a New Anatomy of the Brain, submitted for the Observation of the Author's Friends." Eleven years later, Magendie advanced the same theory, and subjected it to the test of numerous experiments. Contradictory results were however promulgated by different experimenters. It was found difficult to interpret the contortions of the animals experimented on, and to distinguish those which were the result of fear from those which were the effects of pain ; and from this cause it was that for some years an amount of discredit attended the theory. Experiments made upon frogs and other animals tenacious of life, and also upon the human subject, at length put the theory beyond all cavil, and its truth is now perfectly established.

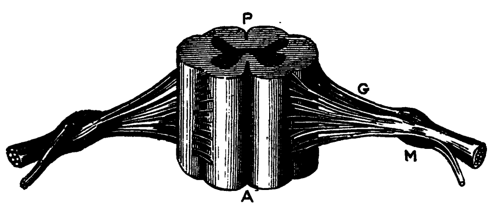
The nerves of the cerebral and cerebro-spinal system are therefore either nerves of sensation or nerves of motion. Those of motion transmit stimulus downwards from the brain to the muscles, and are therefore called efferent nerves. While the nerves of sensation transmit impressions from their terminations upwards towards the brain, and are called afferent nerves. The sensitive nerves, when irritated by touch, pricking, pulling, pinching, or by the application of chemical or galvanic influence, transmit a distinctive impression, of which the sentient principle becomes immediately cognizant. These nerves have no power of exciting motion in the muscles, except by a reflex action, to be afterwards explained. The nerves of voluntary motion, on the other hand, are under the control of the brain, and through it of the will. Stimuli applied to the motor nerves produce contraction in the muscles to which they are distributed, but the patient is unconscious of any sensation. If they be cut through, the limb which they supply is deprived of all power of motion.

A peculiarity connected with the action of the sensitive nerves we may notice. Whatever part of the nerve may be excited, the mind, whether from experience or otherwise, refers the sensation felt to the termination of the nerve. If the nerve be cut across, and an excitant of any kind be

applied above the lesion, the sensation felt is as if it had been applied to the natural extremity of the fibre. It is well known that persons who have been for years deprived of a limb are subject to the same sensations as if it were still the seat of rheumatism, tickling, and pain; and they will occasionally be seen stooping down as if to rub the limb which has been long before severed from the body. From the same cause arises the tingling felt throughout the hand when the nerve at the elbow receives a blow, and which every one must have experienced.

The spinal cord, then, contains the entire sensitive and motor nerves of the trunk of the body—within it as a stem they are all bound up. When cut transversely, it is seen to be divided by anterior and posterior fissures, A and P, cut down nearly to its centre, and leaving only a narrow medial line to connect the two symmetrical halves. The

Fig. 43.



outer portion of the nervous matter of which it consists is composed of white, the inner of grey matter, an arrangement the reverse of that observed in the brain, in which the outer or cortical substance is grey, and the central part is white. Each lateral half of the spinal cord is again obscurely divided by superficial furrows into an anterior and a posterior column, and a smaller middle column runs between them. Those cerebro-spinal nerves G, which issue *from behind* the middle lateral column, are nerves of *sensation*, those which issue in *front* of this column are nerves of *motion*. The nerves of sensation issuing from the spinal cord in the form of fine threads or bands converge together, and unite

in a ganglion M. The nerves of motion, issuing from the spinal cord in similar threads or fibres, without forming any ganglion, converge and enter a common sheath with the sensitive nerves at a point beyond the ganglia of the latter. The fibres of these two sets of nerves, thus indiscriminately received within one cover, are thence conducted to the different parts of the body through the various branchings which the sheaths undergo.

The nerves of sensation, immediately on entering the spinal column, cross over to the opposite side, whence they ascend to the brain ; the nerves of motion, on the contrary, ascend on the side of the column which they enter, till they reach the *medulla oblongata*, where they cross to the opposite side of the head. The result of this arrangement is that an injury or deep cut on one side of the spine produces loss of sensation in the parts below, on the opposite side of the body ; and an injury to one of the cerebral hemispheres, or to one side of the *medulla oblongata*, produces paralysis of the limbs on the opposite side.

CHAPTER XXVI.

THE NERVOUS SYSTEM (*Continued*).

THE BRAIN—WHAT WE KNOW OF IT—THE PRINCIPLE OF BRAIN ACTION, OR ITS FUNCTION AS A PHYSICAL MACHINE—ITS PARTS AND CONNECTIONS—ITS HISTOLOGICAL STRUCTURE—FUNCTIONS OF ITS DIFFERENT PARTS.

HAVING acquired a general conception of the mechanism of the nervous system, our next inquiries are naturally directed to that central organ towards which tend the innumerable nerve fibres distributed throughout the body.

The brain is the immediate and only seat of the thinking and sentient principle. This point, which Galen maintained in opposition to the opinions of Aristotle and some early philosophers, has, as we have shown, been set at rest in recent times by the careful experiments of scientific men; and the proof of such a fact we cannot but regard as on many accounts highly important.

It was natural to conclude that an organ designed to discharge offices in their nature so various and so transcendently important, should be found to possess a structure and mechanism correspondingly complex; and this accordingly has been found to be the case.

Very great labour has been expended in attempts to understand the structure and the functions of this organ, and these have been crowned with considerable success.

One of the foremost peculiarities of the brain is the intimate connection and co-relation of its different parts. Not only do the nerve fibres from the spine and *medulla oblongata* appear to branch off back and fore to different parts of this organ, but the two hemispheres are connected by large commissures, and the anterior and back parts are also connected

by lesser commissures. Numerous fibres are also traced, passing between the different parts, in directions far too numerous for us to attempt describing.

The existence of the arteries, veins, and capillaries, which pervade the substance of the brain, and the extraordinary quantity of blood which is being constantly poured through every part, is another striking peculiarity which marks the large amount of work which is thrown on this organ. The nerve tubes, which form so large a part of its substance, the molecular, fatty, albuminous grey matter which is, as it were, veneered over the surface of the hemispheres, the microscopic cells, or ganglionic corpuscles, which densely pervade this grey matter—all these have been carefully examined, and knowing the active vital properties of cells and ganglia and nuclear bodies, and the quantity of nerve force which they engender in the animal organism, it will not be denied that we have, in some good measure, succeeded in discovering the nature of the action of the brain as an organ of physical and animal power. Its action, both when it receives impressions from the nerves of sensation, and when it sends forth stimulus for moving the limbs, may be described as the discharge of force, and this force is consequent on decomposition effected in the cerebral substance, and especially in the substance of the minute cellular and ganglionic corpuscles, which, as we have said, everywhere pervade the grey matter.

While we can so far contemplate the brain intelligently as a piece of mechanism, admirably framed for being acted on by external impression, and also for generating and directing force to the limbs, under the influence of the mental principle, this is all we can say we understand of its action. It is admitted by all that no physical organ and no physical action, however refined, can afford any explanation of consciousness or thought.

We have in the previous chapter alluded to the great discovery, made by Sir Chas. Bell, of the distinction between the sentient and the motor nerves. This subject has since

his time been successfully prosecuted by various original experimenters. The cognate subject also of *reflex action*, especially since Bell's time, has been investigated; and we may mention, as eminent in this department, the names of Dr. Marshall Hall, Brown-Sequard, J. Lockhart Clarke, and John Reid. The result is that we can now refer most of our involuntary reflex motions to the organ which produces them, whether it be the spinal cord, the *medulla oblongata*, or the ganglia at the base of the brain. We have also ascertained the velocity with which impulses travel through the nerves in the production of sensation and muscular motion.

Simple as this knowledge now appears, such ideas and such language would not have been tolerated during the last century. Physiologists would have discouraged it as fanciful, and mental philosophers would have stigmatized it as degrading. We, living in a more scientific age, receive all such facts with thankfulness. We know that in the co-relation of nature's laws, facts, from whatever source derived, can scarcely fail to help forward all knowledge, mental as well as physical. The attempt in our day to construct a mental philosophy, from which the physical element is entirely excluded, would be received with very little interest by any lover of truth; and as regards our sense perceptions, it is evident that we cannot hope to make the subject intelligible without an adequate acquaintance with the physical laws connected with it. There is need, no doubt, of much discretion, lest in avoiding one extreme we rush blindly into another; and the man who values the higher aims of life, will, in the present day, hold the scales tremblingly in his hands, lest he interpret amiss any of those oscillations which physics and metaphysics are constantly producing on popular belief. It requires much calm consideration before we can determine the full import of new facts.

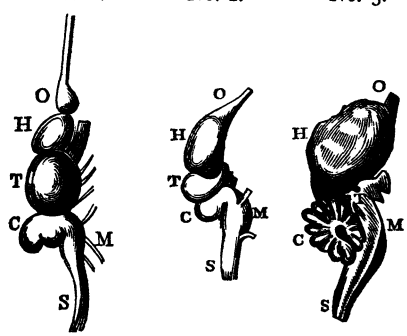
While we repeat, then, that all attempts to explain a physical organ as the appropriate organ of thought are necessarily vain, the question occurs, May it not be pos-

sible, where we assume the mutual action of two factors—a spiritual and a physical—if not to demonstrate, at least to form some rational conception of, the nature of their connection, and to explain the part which the physical element plays in evoking that humbler condition of intelligence which we call sensation, or sense affection? To this point, in its proper place, we shall give some attention. In the meantime, however, let us make some study of the organ with which the mind is in immediate connection.

In the inferior animals the brain is not only relatively much smaller in volume than in man, its parts are also much less crowded and complex. In them we have therefore an opportunity of inspecting the organ in its more rudimentary form, and we are better enabled to pronounce upon what constitutes its essential or more important parts. The vertebrata, which form the highest division of animated beings, alone possess a brain and spinal column. The lower tribes, the *annelida*, *radiata*, *articulata*, *insecta*, and *mollusca*, possess no true brain. Numerous ganglia distributed throughout their bodies supply its place, and from them nerves are given off to all the important limbs and organs.

Fig. 44.

No. 1. No. 2. No. 3.



The magnitude of the brain, and the relative size and position of its parts, vary in different animals, and the changes always proceed in one direction, as we advance from the humbler species up to man. In the brain of all vertebrate

animals we observe certain parts ever present, and which we are, therefore, led to look upon as the rudimentary or essential portions of the organ. In order that we may compare the various parts as they exist in different animals and in man, we give in the preceding figure the types of the brain of different vertebrate animals in an ascending order.

No. 1 represents the brain of the fish; No. 2 of the tortoise; and No. 3 of the bird. In. Fig. 45 we give a section of the human head or brain.

In each of the figures given, the corresponding parts are marked by the same letter, thus :—

S is the spinal cord.

M, the medulla oblongata.

C, the cerebellum.

T, the two lobes called the optic tubercles (corresponding to the corpora quadrigemina in the mammal).

H, the hemispheres of the cerebrum.

O, the olfactory lobes.

These parts exist in the brain of all the *vertebrata*. It will be observed, however, that their relative size varies as we ascend the scale up to man. In the fish (No. 1) the cerebellum is proportionally large, the optic tubercles still more so, the hemispheres small, and the olfactory lobes larger. The parts are also arranged much in a straight line.

In the tortoise (No. 2) the cerebellum and optic tubercles are somewhat smaller, the cerebral hemispheres proportionally larger, and the parts are more condensed.

In the brain of the bird (No. 3) the optic tubercles have assumed a more lateral position, nearer the lower surface of the brain, lying on each side of the *medulla oblongata*. And the cerebellum is partly overlapped by the cerebrum, which has a much greater relative size. The olfactory lobe is much diminished, and the parts are still farther compacted together.

In man the cerebellum is nearly hid under the greatly enlarged cerebrum, while the optic tubercles (*corpora quadrigemina*) are very small, and are quite concealed by the sur-

rounding parts. The olfactory lobes are also small, and are not shown in the figure.

We may give the substance of Dr. Carpenter's views on the cerebrum, as contained in two lectures delivered in St. George's Hall, in November, 1873. (See *Times*, 17th November.)

"The cerebrum of reptiles and birds is not the miniature of that of man. It represents only the anterior lobe of man's cerebrum.

"In the lower mammalia, the middle lobes of the cerebrum sprout from the back of the anterior lobe.

"In quadrumana and in man, the posterior lobes sprout from the back of the middle lobe.

"In connection with this statement, and as rendering the statement more simple and significant, we remark that fœtal observations have shown that in man the front lobe of the cerebrum, which lies at the forehead, first appears, and that the middle lobe, which is immediately under the crown of the head, is next formed, and grows backwards from the front lobe, while the posterior lobe, which overlaps the cerebellum in the occipital part of the head, is last formed, and grows backwards from the middle lobe."

Dr. Carpenter remarks, that as the fore lobe is possessed by all the animals above named, therefore in that part we would expect to find those faculties which man shares in common with the lower animals; and he holds that the experiments, to be after mentioned, of Professor Ferrier, confirm this supposition which he had long maintained. If it be so, then our conceptions of the importance of a well-developed forehead, as a mark of superior intellect, have been premature.

Having given this general sketch of the parts common to all brains, we shall proceed to describe the human brain somewhat more in detail, which will now be more easily done.

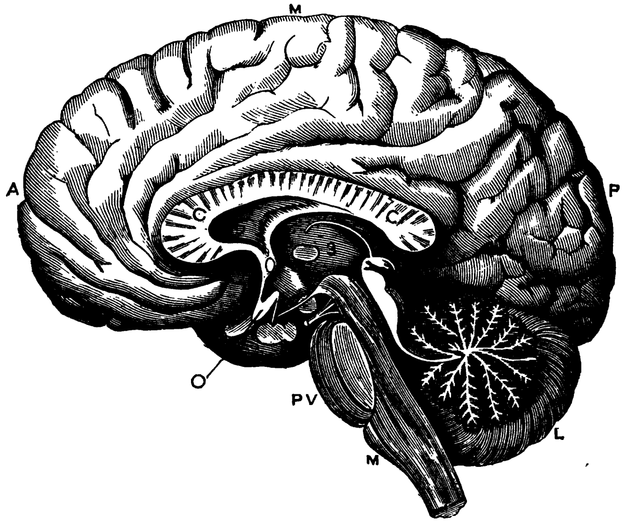
The brain, to the touch, is a soft, pulpy mass, filling the entire cavity of the cranium. It may conveniently be held to be divided into three parts: the cerebrum, or true brain; the

cerebellum, or little brain; and the *medulla oblongata*, which connects these with the spinal column.

The cerebrum is by much the largest portion of the encephalon. It occupies the upper and fore part, and also a considerable portion of the back of the head, where, in man, it overlaps the cerebellum.

The cerebellum occupies a considerable portion of the back of the head, and is to a large extent concealed and overlapped by the cerebrum.

Fig. 45.



Vertical section, showing the right half of the brain.

A M P. The anterior, middle, and posterior lobes of the cerebral hemispheres.
C C. The corpus callosum, or great commissure.
P V. Pons varolii.
M. Medulla oblongata.
L. The cerebellum, or little brain.
O. The optic nerves.
5. The fifth ventricle.
3. The third ventricle.

The *medulla oblongata* passes out of the cavity of the cranium, and entering the vertebral column, is connected with the upper part of the spinal cord.

The cerebrum is distinctly divided into two hemispheres

by a longitudinal fissure which descends through it to its base, interrupted only by the great cerebral commissure, or *corpus callosum*, which by its broad band of white nerve fibres connects the two hemispheres together.

Each hemisphere of the cerebrum is obscurely subdivided, for description's sake, externally, into an anterior, a middle, and a posterior lobe (marked in Fig. 45 A, M, and P.) The whole external or upper surface of the hemispheres is divided by winding furrows, or *sulci*, which descend into it from an inch to an inch and a half; these are called the convolutions. The shape and number of these convolutions obey no absolutely fixed law; in some heads they are more numerous, in others fewer; in some they are more shallow, in others they are deeper cut; and in the same head they are seldom found to correspond exactly in depth, shape, or number in both hemispheres.

The two hemispheres, besides being connected by the *corpus callosum* above mentioned, have various other commissural bands, which connect together their different parts both laterally and antero-posteriorly.

Under the great commissure is the greater ventricle of the brain (the fifth ventricle) and under this again are the lesser or lateral ventricles.

The cerebellum, or little brain, is less than a third of the cerebrum in size. It occupies the lower and posterior portion of the head. Like the cerebrum, it is divided into two hemispheres, which have something like the appearance of two flattened spheres pressed against each other; viewed externally these appear to consist of flattened layers, separated by grooves or fissures, which thus, in some respect, correspond to the *sulci* between the convolutions of the cerebrum, though they are much deeper. The arrangement of these deeper layers, when a vertical section is made through the hemispheres of the cerebellum, presents an arborescent appearance. A thick mass of white substances is seen in the centre, from each side of which layers proceed as from a stem, from

which circumstance it has received the designation of *arbor vitæ;* of these layers there are usually from 30 to 35 on the upper surface, and from 24 to 30 on the lower side; but on separating them we perceive many other strata, similar in form, but smaller and thinner, concealed in the grooves and overlapping each other.

The front of the cerebellum, and occupying nearly the centre of the back of the brain, of which it weighs about a sixtieth part, is a large circular mass of nervous matter, P V, called *tuber annulare,* or *pons varolii.* This tubular-looking mass of fibrous matter sends out two thick strands or prolongations towards the under part of each hemisphere of the cerebrum, and two similar cords or strands backwards, towards each hemisphere of the cerebellum; these are called the *crura* or legs of the cerebrum and cerebellum, which may thus be considered as connected together in this tubular-looking mass by means of those four *crura.* (See also Fig. 46 in next chapter.)

Regarding the three important ganglia at the base of the brain, we may mention the *corpora striata,* one connected with each hemisphere; next behind, and situated on the upper surface of the *pons varolii,* are four small tubercles, which lie close together in a quadrangular position, these are the *corpora quadrigemina;* and below this are the *optic thalami.* We may mention also the pineal gland, a small, solid, greyish body of the size of a large pea, which appears at the base of the brain. It possesses no particular claim on our attention, except as having been supposed by Descartes to be the seat of the soul.

The *medulla oblongata,* which connects the *pons varolii* with the spinal cord, consists of six oblong continuous columns; namely, the two anterior, and the two posterior pyramids, which seem externally to arise from the lower part of the *pons,* and, after descending about an inch, enter the upper part of the spinal cord. The other two columns are the restiform, or rope-looking bodies, which run parallel and immediately behind the anterior pyramids on each side; and

between them and the posterior pyramids are two oblong or oval bodies, called the *corpora olivaria*, or olivary bodies. (See Fig. 46 in next chapter.)

If the *medulla oblongata* be carefully drawn asunder at its grooves, there will be discovered four or five bands of a white substance, ascending obliquely, and crossing from one side of the medulla to the other, as if interwoven. These—the decussating bands of the pyramids—are the motor nerve fibres collected from either sides of the body, which are here seen to cross to reverse sides of the brain.

The brain being of a soft consistence is secured in the cranium, and its parts are supported by the *dura mater*, which is of an exceeding tough and fibrous texture, and lines the entire cavity of the head to which it adheres. Beneath the *dura mater* a second membrane invests the brain, called, from its structure, which has a supposed resemblance to a spider's web, the *arachnoid* membrane. This thin, colourless, and transparent membrane is spread uniformly over the surface of the brain, but does not insinuate itself between the convolutions. The third investing membrane is the *pia mater*, which derives its name from the delicacy of its tissue; but unlike the *tunica arachnoidea*, in which not a blood-vessel has been discovered, the *pia mater* is exceedingly vascular. Its close network of blood-vessels, before they penetrate the brain, divide and subdivide to an extreme degree, evidently in order that the blood entering the soft cerebral substance may not be propelled through it with injurious force. This membrane, which contains the nutrient vessels of the brain, is not only spread over its surface, but descends into all its convolutions and layers. Indeed, the main object of the convolutions would seem to be that a larger surface may be exposed to the influence of the arterial current, and that the brain may thus, through the numerous capillaries, have the quicker means of nourishment and restoration.

As the brain is so important an organ, being in a great measure the source of the energies of the whole body, it is

supplied with blood to a corresponding extent. It has been computed that so much as one-fifth of the entire blood sent out of the left ventricle of the heart is carried to the head, and yet the weight of the brain is not more than one-fortieth part that of the whole body.

Let us now endeavour to acquire some conception of the substance, or histological constitution, of the brain. It is not homogeneous. The surface of the cerebrum, including that of its convolutions, consists of grey or cineritious matter. When examined under the microscope, this part is found to be much more vascular than the white substance which lies below. The grey matter is composed of molecular matter, in which are imbedded ganglionic corpuscles and nucleated cells of various sizes and shapes. These are frequently found to be connected together by nerve fibres of different fineness. The white matter which lies below the grey surface, and which constitutes the main under-substance of the brain, is fibrous, consisting of nerve tubes closely packed together. In the cranial portion of the spinal cord, grey matter also exists in masses, constituting a chain of ganglia, the parts of which are more or less connected with each other, as well as with the white matter of the brain proper above and the vertebral portion of the cord below.

Within the spinal cord the grey matter occupies the interior; and on a transverse section being made, it there presents the form of the letter X, having two posterior and two anterior cornua, or horns. These are surrounded by white fibrous substance, which, issuing out in the direction of these cornua in the way mentioned in the previous chapter, form the posterior or sensitive, and the anterior or motor cerebro-spinal nerves.

On tracing the spinal cord upwards into the brain, we observe that the anterior pyramidal columns of the *medulla oblongata* send off one bundle of the nerve fibres to the cerebellum. The principal portion, however, is sent forward from it through the *corpus striatum* and *optic thalamus*, and is

ultimately lost in the white substance of the cerebral hemispheres. The middle column, or olivary tract, may be likewise traced through the *optic thalami* and *corpora quadrigemina*, to be in like manner lost in the cerebral hemispheres. The posterior columns and restiform tracts pass fibres almost entirely to the cerebellum.

Regarding the relative functions of the grey and white matter: the grey with its various cells and ganglionic corpuscles, wherever it exists, whether in the cerebral hemispheres, in the *medulla oblongata*, or in the spinal cord, is the source of nerve force. The white substance, consisting chiefly of nerve fibres, is supposed merely to conduct, not to originate nerve influence. The cerebral hemispheres, and especially its grey, cineritious, or cortical matter, is supposed to be the part of the brain immediately connected with the operations of intelligence.

In consistence with what might be expected from the structure of the organ, as here described, it is found that injuries to the base of the brain, and to the *medulla oblongata*, are much more fatal than injuries to the surface of the hemispheres, or to the cerebellum; just as the cutting of the stem or the root of a tree is more fatal to the living plant than the pruning of its branches, because in the former case we interrupt the entire current which supplies the element of life.

The experiments made by Flourens, Roland, Hertwig, McKendrick, and others on pigeons have proved that the cerebral hemispheres and *corpora striata* may be almost entirely removed without the life or the muscular powers of the birds being destroyed. The result is deafness, blindness, and the loss of all desire to originate motion. We have seen a pigeon so mutilated which stood well on its feet, perched on the finger, drew up its foot when the toe was pinched, and even preened its feathers in an absent, hopeless way. Its life seemed a state of somnambulistic unconsciousness. It was apparently a living machine—the most painful of all sights.

Such animals, by the operation of reflex action, swallow food when it is put well back in the mouth; and they often live for many months if duly fed.

The cerebrum, then, there can be little doubt, is the part most closely connected with voluntary action and voluntary thought; and comparative anatomy teaches that the amount of intelligence in different animals bears a constant relation to the size of this part of the brain. It is the same in the human subject, there is a general correspondence between the size and weight of this part of the brain and the amount of intellectual power. In idiots the cerebrum is generally either small and ill-developed, or diseased, or in some way defective, and the convolutions are frequently very ill-defined, or nearly absent.

The central grey portion of the spinal column, and also the grey matter of the hemispheres, we are assured by operators, are insensible to direct impressions,—such as pressure or incision,—and portions of the surface of the human brain have been removed by the knife without any sensation of pain being experienced. It is narrated, we think by Dr. Abercromby, that on probing into the substance of the brain with his finger in search of a musket ball, the only sensation the patient admitted when questioned, was the contact of the finger with the external edge of the wound. It is certainly a strange and noteworthy fact that that part in which impressions from all the external parts of the body are perceived, combined, weighed, and stored up, should itself be devoid of sensation; surely no stronger proof can be afforded that the human organism is expressly framed for the operations of animal life, and that the brain is that part of the machine which is formed, not for feeling or thinking, but for the precise purpose of informing the spiritual principle, by its peculiar physical action, of the condition of the organism, and to do which it must receive its impressions in a specific way, or the mind can take no cognizance of them. Itself is unconscious and unsentient—a mere piece of mechanism, contrived and placed to establish a connection between the

outer world and that sentient principle whose existence materialists deny.

Instances are recorded of extensive injury done to the hemispheres, both by disease and by violence, where the mental powers were yet not deranged; the remaining parts here seemed sufficient to discharge the necessary function, whatever that may be.

Removal of one hemisphere produces blindness on the opposite side. A pigeon on which this experiment was performed was blind on the opposite side, but saw perfectly well with the eye on the injured side. Blindness is also produced by mutilation of the anterior part of the *corpus quadrigeminum*, the *thalami optici*, and generally of any of the deep-seated parts of the brain.

Magendie having cut one of the *crura cerebelli*, the animal made sixty revolutions in a minute, and this sometimes continued for a week without cessation. Division of the *crura* of the opposite side restored the equilibrium, and the rotatory movement ceased. Injury to one side of the *pons varolii* always caused the animal to fall over on that side.

The cerebellum is found to have an important function in connection with voluntary motion. When a considerable portion is removed, the animal, though it retains muscular power, is deprived of all ability to regulate its movements. It exhibits extreme terror, which is all the more powerful, doubtless, from the consciousness of its inability to escape from its tormentors. In this respect the contrast between the functions of the cerebrum and the cerebellum is very striking. It is a curious fact, which has come under the experience of Dr. McKendrick in some of his extensive experiments, that birds on whose cerebelli this mutilation was inflicted, after an interval of months frequently recovered the control of their movements. It would be interesting to know whether in such cases the mind acquired the ability of managing a defective machine, or whether nature restored the injured part.

We cannot conclude these brief notices on the functions of the different parts of the brain without referring to the important experiments brought under the notice of the British Association at Bradford, in 1873, by Professor Ferrier, and some of Dr. Carpenter's comments, as given in his lectures already alluded to.

Former experimenters were led to their conclusions on the functions of the brain, either from the effects of disease on particular parts of that organ discovered on *post mortem* examination, or by removal of different parts. The effects thus produced afforded, however, only a negative proof. A different method of experimenting was therefore, about three years ago, commenced by two German physiologists, Fritsch and Hitzig, viz. by passing galvanic currents through distinct parts of the brain of various animals, and observing the peculiar movements elicited. Professor Ferrier has followed up these experiments with great zeal and a certain measure of success. He has experimented on upwards of 100 animals of all kinds. His plan was to remove the skull, and keep the animals in a state of insensibility by chloroform. The results were that the stimulus of galvanism produced an increased flow of blood to the parts so excited, and an augmented activity.

He found that the application of the electrodes to parts far apart produced general convulsions, but on bringing them nearer, so as to excite only a particular convolution, or part of a convolution, he could call forth co-ordinated movements of particular groups of muscles; such as action of the jaws, the legs and feet, the tail, the head and neck.

The conclusion he arrived at was that the centres of all these movements were located in the anterior lobes, and in the anterior portion of the middle lobes.

He found that no motion was called forth by the application of stimulus, either to the posterior parts of the middle lobes of the cat or dog, or to the posterior lobes of the monkey, while the forward prolongations of their anterior

lobes were equally irresponsive. Here, says Dr. Carpenter, we have confirmation of the inference drawn from comparative anatomy, that the posterior lobes are the instruments of the higher operations regulating the ideas, and which do not prompt to action or movement.

We have only to remark in connection with these interesting experiments, that we are not yet disposed, and without further inquiry, to surrender our admiration for the forehead as the seat of intelligence, and transfer it to the back part of the head.

CHAPTER XXVII.

THE NERVOUS SYSTEM (*Continued*).

THE CRANIAL OR CEREBRAL NERVES.

As the preceding chapter on the brain has extended beyond what we would have wished, we have thought it right to give the enumeration of the cranial nerves in a separate chapter.

Under the system of Sömmerring, there are said to be twelve pairs of cranial nerves, and under that of Willis, which we here follow, there are said to be nine pairs. The two first pairs, viz. the olfactory and the optic, issue from the *brain*, all the others issue from the *medulla oblongata*. The nerves which issue from corresponding parts on each side of the head are called *a pair*. They are usually numbered and designated according to the order in which they issue from the encephalon, commencing by the foremost and counting successively downwards and backwards. This method materially assists the memory. In thus describing nerves geographically, it must be kept in view that the description has no reference to the ultimate origin of the nerve-fibres within the brain.

The first pair (1) consist of the two olfactory nerves, which issue directly from the fore-part of the base of the cerebral hemispheres. They contain grey matter mixed with white nerve tubes, and thus resemble gangliar and brain substance.

The second pair (2) are the two optic nerves, which issue from the walls of the third ventricle.

The third pair (3), called *motores oculi*, regulate all the movements of the eyeball, except the two which depend

on the action of the external rectus and superior oblique muscles.

The fourth pair (4) supply the trochlearis, or superior oblique muscle of each eye, with motor power.

The sixth pair (6) we mention next, because they govern the movements of the *external rectus muscle* of each eye. Thus the motor muscles of the eyes, small and confined as they are, and special and limited as seem their functions, receive their power of motion from three pairs of nerves, issuing from different parts of the brain, namely, the third, fourth, and sixth pairs; and it is a singular consideration that, in turning the eyes to one side, the third nerve acts on one eye, and the sixth on the other, in order to produce parallel motion.

The fifth pair (5) divide into three branches, two of which are purely sensitive, and the third is a senso-motor, or mixed nerve. It further resembles a spinal nerve by having a ganglion on its sensory root. They supply the skin of the face and the muscles of the jaws, and having three chief divisions are called trifacial or trigeminal.

The sixth pair have been given fifth in order.

The seventh pair (7) are composed of two separate nerves which issue from the same cavity.

The hard portion, or *facial nerve*, is a motor, and governs the movements of all the muscles of the face.

The soft portion is the *auditory nerve*.

Note.—These two branches are frequently called the seventh and eighth pairs.

The eighth pair (8) are divided into three branches, viz. :—

The *glosso-pharyngeal*, distributed to the tongue and pharynx, is a nerve of sensibility, ministering taste and touch in the former situation, while it is the great excitor of deglutition in the latter.

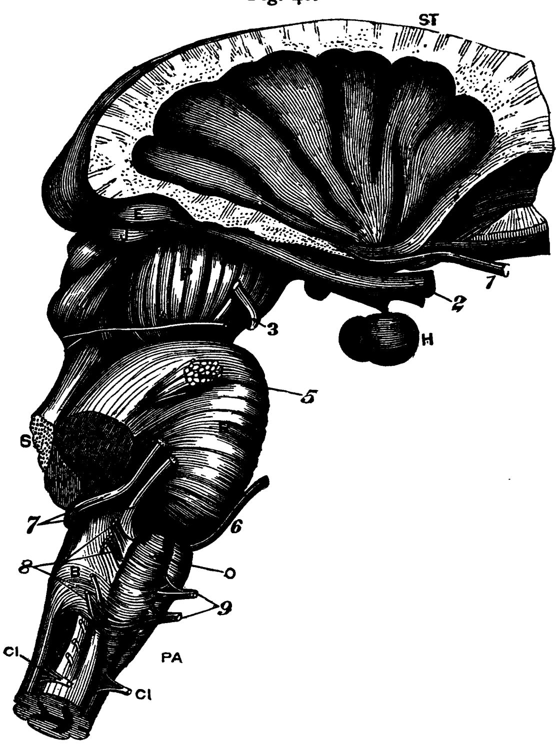
The *par vagum*, or pneumo-gastric nerve. Its branches have different functions. One branch, as the name suggests, supplies the larynx and lungs, also the liver and stomach, with nerve power. It also sends some branches to the heart.

The *spinal accessory* is a motor nerve, the external division supplies the external muscles of respiration, and the internal division sends fibres to the vagus, thus probably regulating the functions of the larynx and chest.

Note.—When the second nerve of the seventh pair is called the eighth pair, the eighth becomes the ninth pair, and its second and third branches are called the tenth and eleventh pair.

The ninth pair (9), or *hypoglossal*, is the motor nerve of the tongue.

Fig. 46.



This figure gives a view of the central portion of the brain, showing the points where the cerebral nerves issue from it.

S, M and I N, mark the superior, middle, and inferior peduncles of the crus cerebelli cut short.

CHAPTER XXVIII.

THE NERVOUS SYSTEM (*Continued*).

FUNCTIONS OF THE NERVOUS SYSTEM—THE SYMPATHETIC NERVES—REFLEX ACTION—CONSENSUAL OR SENSORI-REFLEX ACTION—VOLUNTARY MOTION—ANIMAL INTELLIGENCE—MENTAL ACTION WITH APPARENT UNCONSCIOUSNESS—DIFFICULTY OF ACQUIRING NEW MOVEMENTS—ULTIMATE FACILITY—EXPLANATION—HOW FAR MAN IS A MACHINE—THE DIRECTING POWER.

WE must now consider those distinctly different functions of the nervous system, or systems, which have reference—

First, to organic action;

Second, to reflex involuntary movements;

Third, to voluntary motion.

Thus we shall more completely understand the nature of the animal machine; for we must regard the body even of the higher animals, not excluding man, as holding to a certain extent the position of a machine which works irrespective of the will or intelligence of the possessor.

First, then, in this connection let us allude again to the sympathetic system, with its ganglia, which, distributed throughout the inner parts, supplies the heart, stomach, intestines, and other internal organs with functional and motor power. These nerves seem, in themselves, to possess no direct power of communicating sensations to the mind. It is, as we have already said, a maxim in animal economics that during health we are unconscious of the working of any of our internal organs—their operations are automatic, silent, unfelt. It is only during disease, or abnormal action through the fibres of the cerebro-spinal nerves, with which they have numerous connections, that the mind is, when necessary, made aware of disturbance or disarrangement in the organic department of the animal corporation.

Second. Although the cerebro-spinal system of nerves is the medium alike of sensation and of voluntary action, yet it is certain that the *medulla oblongata*, the spinal cord, the ganglia at the base of the brain, and at times also the cerebrum, act much on the same principle as the sympathetic system does, in producing certain involuntary yet necessary movements of the inner organs of the body. We may enumerate a few of these reflex acts. In the first place, there are respiration and deglutition; then we may mention the involuntary convulsive actions, known as sneezing and coughing, produced by the discharge of nervous energy consequent on the irritation of the nerves of sensation which line the fauces and nostrils; or it may result from irritation of the eye. Then, again, there is the expansion and contraction of the iris to regulate the admission of light to the retinæ. Again, there is the constant act of winking, which follows the irritation of the surface of the eye from lack of moisture, or any other cause; and, lastly, we may mention, as a good illustration of the nature of involuntary reflex action, the convulsive movements produced by tickling the soles of the feet and other sensitive parts of the body. And of the same nature is laughter, when brought on by mental causes. Certain whimsical ideas produce, it is well known, an involuntary and irrepressible discharge of nerve energy, which, through the pneumo-gastric nerve, convulses a number of powerful muscles connected with the chest.

All these reflex muscular movements are the result of an excitement sent by the sentient nerves to the *medulla oblongata*, spinal coloumn, or the ganglia at the base of the brain, and a consequent discharge of nerve force through the motor-nerves leading to the muscles; and it will be observed that frequently; as, for instance, in sneezing and coughing, a totally different set of muscles is brought into action from those to which the irritation is applied.

The same reflex action occurs whether we are asleep or awake; and what is still more strange, many reflex actions

may be produced even in the recently dead body. The experiments of Galvani upon dead frogs have been long known; the same phenomena may be exhibited in man and in other vertebrate animals. Galvanic or mechanical stimuli, such as the act of pricking or pinching the muscle or the sensitive nerves of a dead subject, is followed by spasmodic movements of the muscles affected. Reptiles and amphibia, such as frogs and salamanders, are especially susceptible of reflex nervous action, and the feeblest agency is sufficient to excite it. If we cut off the heads of such animals, they will continue standing quietly on their legs, but on the toe being pinched, or the skin even slightly touched, they are thrown into violent convulsions. This sensibility continues for many hours after death, and the movements are exhibited by every separate portion of the body in which there is a nerve connected with the spinal cord. We must attribute this action to that susceptibility to chemical change which distinguishes the brain, spinal cord, and in general all nervous tissues—a susceptibility which muscular fibre, irrespective it would seem of the nerve fibres which pervade it, also possesses.

A continued repetition of the stimulation gradually exhausts this nerve power, after which it is found difficult to obtain a renewal of the phenomena.

In connection with the important subject of nerve and muscular action, and the operations of animal life, it may be instructive to state the views of Dr. Carpenter ("Human Physiology"). This will afford us the best opportunity of considering the subject, more especially since we consider that his conclusions require modification. As a non-professional person, the author would desire to express his opinions with becoming deference, but here, as everywhere else, he reserves the fullest liberty of criticism.

Dr. Carpenter, in discussing the subject of animal action, commences with the consideration of nervous systems of the simplest conceivable type, actual or possible, and extends his reflections to the nervous systems of higher animals.

Invertebrate animals possess no true brain. What comes in its place may more properly be considered as cephalic ganglia.

Case first. The nervous system in its simplest conceivable form, Dr. Carpenter suggests, may consist but of a single ganglionic centre, with afferent and motor nerves. Impressions here made on the afferent nerve fibres would excite reflex movements in the parts supplied with the appropriate motor nerves without any intervention of consciousness. Such a case is purely hypothetical, and is suggested merely to explain the nature of pure excito-motor action, irrespective of sensation or the intervention of animal will. If such an organism existed, it would be a plant as regards insensibility, but yet a step towards the animal in respect of possessing a nervous system.

Case second. A simple repetition of such ganglionic centres may exist in more complex animals, but the several centres may be so connected by commissural fibres that an impression made upon the afferent nerves of any one of the ganglionic centres may excite respondent motions in the other segments. This we see effected through the annular gangliated cord of the higher *radiata*, and through the longitudinal gangliated cord of the *articulata:* the disposition of the ganglia and their connecting cords having reference simply to the general plan of the body of the different animals.

Case third. A higher form of nervous system is that in which, over and above such ganglia as we have referred to, and which exist for the purposes of locomotion, there are superadded ganglia for the exercise of separate and specific functions; thus, in the higher articulated and molluscous tribes, there are ganglionic centres specially set apart for the action of deglutition and respiration, but their action may be (Dr. Carpenter says *is*) possibly still mere excito-motor, or reflex action, without the necessary intervention of consciousness; a consentaneousness of action being preserved by reason of the connections existing between the various centres.

Case fourth. In all but the very lowest invertebrata the nervous system includes, in addition to the foregoing, certain ganglionic centres situated in the neighbourhood or at the entrance of the digestive cavity, and which are also connected with organs which, from their more or less close resemblance to our own instruments of special sense, we conclude to be organs of sight, smell, hearing, etc. Now, as we know from our own experience that impressions made upon these organs produce no influence on our actions unless we become *conscious* of them, and as the invertebrata possess no distinct ganglionic centres of a higher character, it seems to be a legitimate inference that these *sensorial* ganglia are the instruments by which these animals are rendered cognizant of such impressions, and that these ganglia thus serve to prompt and direct their movements. What is commonly designated as the brain of an invertebrate animal (more properly its cephalic ganglia) cannot be shown to consist of anything else than an assemblage of *sensorial* centres; and its actions appear, says Dr. Carpenter, to be entirely of a reflex character. Such of the movements of these animals as are not excito-motor—being performed (there is reason to believe) in direct respondence to sensations excited by internal or external impressions—such movements may be designated as *sensori-motor*, or *consensual*. Like the preceding, they do not appear to involve the participation either of emotion, reason, or will. In whatever way the various excito-motor centres may be connected together, we uniformly find them connected with the sensory ganglia by commissural tracts. Besides the reflex actions which are performed in these animals through the instrumentality of the sensory ganglia, it seems probable that a stimulus is transmitted downwards from these to the excito-motor ganglia; thus a stimulus transmitted from the sensory ganglia to one of the ganglia of the trunk of a centipede, will excite the efferent or motor nerves of that ganglion, and call into contraction the muscles through which these motor nerves are distributed, just as an

excitor influence, unaccompanied by sensation, arriving at that ganglion through its own afferent nerves would do.

The whole nervous system of invertebrate animals, then, says Dr. Carpenter, may be regarded as ministering entirely to *purely reflex* action, and its highest development, as in the class of insects, is coincident with the highest manifestation of the *instinctive* powers which, when carefully examined, are found to consist entirely in movements of the excito-motor and sensori-motor kinds; and we can scarcely fail to arrive at the conclusion that the *adaptiveness* of the instinctive operations of insects lies in the original construction of their nervous system, which causes particular movements to be executed in direct respondence to certain impressions and sensations. They are thus to be regarded as entirely creatures of necessity, performing their instrumental part in the economy of nature from no design or will of their own, but in accordance with the plan originally devised by the Creator.

Dr. Carpenter next considers the nervous system of the *vertebrata*. He holds the cranio-spinal axis, which consists of the spinal cord, the *medulla oblongata*, and what he calls the sensory ganglia at the base of the brain, as the centres of automatic movement, and therefore as the fundamental parts of the cerebro-spinal apparatus of man, as of the inferior vertebrate animals. This, says he, is apparent when we consider the formation of the brain of the humbler members of the vertebrate class, as, for instance, of the fishes. All these possess the parts we have mentioned, but the part corresponding to the cerebral lobes is in every instance very small, and in certain lower fishes it seems all but absent. In one small fish, the *amphionus*, there is not a trace either of the cerebrum or cerebellum, and even the sensory ganglia are only in a rudimentary state, and yet the parts they possess are quite sufficient for the performance of all their actions. This condition has its parallel even in the human species, as in the case of infants which are occasionally born without either cerebrum or cerebellum, and which have existed for several hours, or

even days, breathing, sucking, crying, and performing various other movements.

In further support of this opinion, says Dr. Carpenter, it is worthy of note that no sensory nerves terminate directly in the cerebrum, nor do any motor nerves issue from it; and there seems a strong probability that there is not a direct continuity between any of the nerve fibres which are distributed to the body, and the medullary substance of the cerebrum; for while the nerves of special sense have their own ganglionic centres, it cannot be shown that the nervous fibres of general sensibility, which either enter the cranium as part of the cephalic nerves, or which pass up from the spinal cord, have any higher destination than the *thalami optici;* and so also the motor fibres, which pass forth from the cranium, either into the cephalic nerve trunks, or into the motor columns of the spinal cord, though commonly designated as *cerebral*, cannot be certainly said to have a higher origin than the *corpora striata;* and he holds that there are strong physiological as well as anatomical grounds for the belief that the cerebrum has no communication with the external world otherwise than by its connection with the sensori-motor apparatus.

This is merely Dr. Carpenter's opinion, which is at variance with that of many other physiologists.

With regard again to the cerebellum, he adopts the opinion, which we think is more than probable, that it is rather concerned in the regulation and co-ordination of the actions dependent on the spinal cord than on any proper mental operation.

The conclusions, therefore, to which this writer comes, are—

First. That the spinal cord, and the sensory ganglia at the base of the brain, are the special centres of reflex action.

Second. That it is owing to this involuntary action that many of our organic functions, such as respiration, swallowing, and some others, are sustained without the interference of the will, or of its organ the cerebrum.

Third. That every segment of the spinal cord, and every one of the sensory ganglia, is a sufficient and independent centre of nervous power, and a cause of reflex action; and though these reflex operations may, in the case of the vertebrata, be interrupted and controlled by the exercise of the will, through its organ the cerebrum, yet, that they are more steady in their action when the parts on whose influence they are dependent are separated from the encephalonic centre, and the interference of the will is cut off.

Thus, if the spinal cord is divided, and the lower part is deprived of communication with the encephalic centres, the isolated portion acts as an independent centre, and impressions made on it through the nerves of sensation, in the lower extremities, excite reflex movements. These, seeing they are produced without sensation, are purely excito-motor movements.

So, again, if the impressions are conveyed to the cerebral ganglia, or sensorium, but are prevented by the removal of the cerebrum, or by disease, or by its being in a state of functional inaction, or from the activity of that part being directed into a different channel, the external impression will, nevertheless, act on the motor apparatus by the reflex power of the sensory ganglia. Such seems to this author to be the rationale of those locomotive actions which are maintained and guided by sensations during states of abstraction, as when the attention is so concentrated upon a train of thought that the individual does not perceive external objects, although his movements are obviously guided by means of the visual and tactual senses. Such actions, says Dr. Carpenter, it is thence to be inferred are dependent on the prompting of sensations independent of any interference of the will; and such movements this writer accordingly calls sensori-motor, or *consensual*. But, farther, says he, even the cerebrum responds automatically to impressions fitted to excite it to reflex action, when from any cause the will is in abeyance, and its power cannot be exerted either over the muscular

system, or over the direction of the thoughts. Thus, in states of reverie, dreaming, somnambulism, etc., ideas which take possession of the mind, and from which it cannot free itself, may excite respondent movements; and this may happen also when the force of the idea is morbidly exaggerated, and the will is not suspended, but merely weakened, as in many forms of insanity.

Then, as to the correlation of function existing between these sensory ganglia and the cerebrum, which is the supposed seat of volition, Dr. Carpenter proceeds thus. There is very strong physiological evidence that the sensory ganglia are not merely the instruments whereby our voluntary movements are directed and controlled, in virtue of the guiding sensations which they furnish, but that they are also the immediate centres of the motor influence, which excites muscular contractions in obedience to impulses transmitted downwards from the cerebrum. It has usually been considered that the cerebrum acts directly upon the muscles, in virtue of a direct continuity of nerve fibres from the grey matter of its convolutions through the corpora striata, the motor track of the medulla oblongata, the anterior portion of the spinal cord, and the anterior roots of the nerves; and that in the performance of any voluntary movement the will determines the motor force to the muscle, or set of muscles, by whose instrumentality it may be produced. To this doctrine, however, anatomical facts constitute a very serious objection, for the motor track cannot be stated with certainty to have any higher origin than the corpora striata; and it is impossible to imagine that the fibres which converge towards the surface of these bodies, from all parts of the cerebrum, can be so closely compacted together as to be included in the motor columns of the spinal axis.

Now, it may be asserted with some confidence, that no effort of the will *can* exert that direct influence on the muscles which our ordinary phraseology, and even the language of scientific reasoners, would seem to imply; but, on

the other hand, that *the will is solely concerned in determining the result;* the selection and combination of the muscular movements required to bring about this result not being effected by the will, but by some intermediate agency. If it were otherwise, we should be dependent upon anatomical knowledge for our power of performing the simplest movement of the body. The power of the will is really limited to the *determination of the result;* and the production of that result is entirely dependent upon the concurrence of a *guiding sensation*, which is usually furnished by the very muscle that is called into action. It is obvious, therefore, that we must seek for some intermediate agency which executes the actions *determined* by the will ; and when the facts and probabilities are duly considered, they tend strongly in favour of the idea that even voluntary movements are executed by the instrumentality of the automatic apparatus, and that voluntary movements differ only from automatic or instinctive in the nature of the stimulus by which they are excited. The cerebral influence, determined by the will, being the exciting cause of the action of the sensory ganglia in all voluntary movements, while the sensory impressions of light, touch, hearing, smell, etc., sent through the nerves of sense, are the exciting cause of the action of these sensory ganglia, in the involuntary movements sustained by them.

This seems to us an ingenious and well thought out theory, and it is probable that there is much important truth in it. But Dr. Carpenter in his treatment of the subject seems far too much to favour the machine theory of animal action. Thus, first, he limits, if he does not entirely disallow, the intelligence of invertebrate animals. We do not believe that any class of animals, if it be not some of the lowest aquatic creatures possessing no powers of locomotion, can be likened to machines, with sensation superadded. Every animal, we suppose, must have a consciousness of its individuality—a will of its own, a love of life, a sense of enjoyment, and ability to minister to its enjoyments. All

their movements, and especially their leading daily avocations, indicate that they are influenced by an object. When the spider, for instance, weaves its web and lies concealed in a dark corner which itself has formed, how can we avoid concluding that it has an object in view? Is it possible to study the contrivances of this creature whose life is so suggestive, and whose organism is so wondrously fitted to carry on the purposes of its being, and come to the conclusion that it has not the soul and spirit of a predatory animal? The supposition seems preposterous. Whatever may be the difficulty in assigning the part of the creature's body within which the mental principle may be lodged, still that it has such a directing principle no one who watches it can possibly doubt.

It seems to us that the larger portion of animal enjoyment is strictly mental and not physical—such is the building of nests, the construction of houses, the weaving of nets, the storing of food, the nourishing of the young, the tumbling and gambolling with their fellows, in which many of them indulge; these and many other acts imply mental conditions in close analogy with what the lords of the creation possess. We confidently say that no imaginary machine, however ingeniously designed and sensitized, can be conceived capable of fulfilling a hundredth part of the daily doings of the humblest invertebrate animal. No blind reflex motion can explain any of the leading acts of animal existence. Reflex action could not even place an animal on its legs were it to lose its centre of gravity. Insects have numerous wants and cravings, and they have wonderful instincts which enable them to gratify them. It is perfectly gratuitous, however, to imagine that the execution of the acts which these instincts prompt is removed beyond the circle of volition and intelligence; on the contrary, we see that, far from suspending mental exertion, these appetites and these instincts serve to stimulate the mind to unwonted acts of ingenuity, energy, and courage. The

theory, therefore, that external impulses on certain nerves call forth appropriate movements of the limbs, and that all these are so adjusted that, without the exercise of intelligence or choice, the humbler animals perform the operations of a busy life, this we think is a mistaken theory of animal existence. Some persons, simply because they have never thrown themselves into sympathy with the lower animals, will scarcely admit that a dog has intelligence. The loving observer, on the contrary, interprets the significance of every look; he knows that the thousand movements of the ears, eyes, muscles of the forehead and tail, mark as many inward emotions of joy, sorrow, doubt, fear, and disappointment. In his boisterous moods, what boy is fuller of broad rough humour than a dog; in his sober moments, what lady is more observant of etiquette, what courtier is more jealous of his place and dignity. Some animals have, doubtless, very little head; but then we may say the same of many men and women—they will walk right forward on the wrong road; they will leave their baggage or their children behind them on a journey—even philosophers will sometimes do as bad as this. We suspect, however, that in spite of these proofs of imbecility, all these act generally on some leading idea, and that it is not a mere opening and shutting of nerve valves, caused by impulses from the soles of the feet, that carries them through the world.

That the mind has the habit of disburdening itself of the details implied in locomotion, every one must have observed. It has higher duties which engross it; but still we know that, without a distinct exercise of will, neither the biped, nor the centipede, nor even the asteroid, with its uncounted number of ambulacral organs, will progress satisfactorily.

There may be a tendency in the brain to repeat a succession of movements which it has previously performed. In some circumstances we know this to be the case. Thus we know when the brain has been excited by continuous

mental exertion that it is very difficult to discharge the subject from the mind. The brain being in an abnormal and excited state keeps it before us in spite of every effort. This physiological phenomenon is insufficient, however, to explain voluntary actions.

On the other hand, we know the difficulty with which we first learn to perform any new series of movements. Before a boy, for instance, can be initiated into the performance of a new dance step, the utmost stretch of attention is required. When once apprehended, however, and repeated several times, the *entente cordiale* between the will and the muscles seems to become established, and soon the movements flow on as in a physico-mental rhythm, and the details both of the mental and the bodily efforts cease to occupy the attention. The mind, inspired by the spirit of the piece, becomes so unobservant of the part it plays, that it seems rather as if the piece carried the performer on, than he the piece. From this facility ultimately acquired many persons may be disposed to argue that the mind ceases to direct the movement. In this we cannot concur; we would rather explain it thus: when we have thoroughly acquired the rhythm of any performance, our consciousness of the part we are each moment engaged with suggests the part that is next to follow. There is no need of effort to seek it; there is an association and memory of the symmetry and balance of the piece which presents itself and makes it far more difficult for us to go wrong than to preserve the proper succession of movements.

How is this to be explained? and, first, Whence arises the difficulty we experience in acquiring any new series of bodily movements? Certainly it is not that the limbs, at the first attempt, are not subject to the will. Before we reach boyhood we have acquired a command over our limbs for all ordinary work; therefore the difficulty lies not there. The difficulty arises, we apprehend, chiefly from the complexity of the movements required, a complexity far more intricate

than, without careful examination, we could believe. The mind must evidently learn these in detail before the necessary actions can possibly be performed; and to acquire these details, and the necessary amount of dexterity, any one who tries will find to involve an amount of pretty hard study. When, however, the particular movements, their direction, their succession, and the force and duration of each have been acquired, as in dancing, swimming, skating, riding, etc., the movements become ours in every respect, and they are never forgotten. We neither require to keep the limbs nor the brain in constant practice in order to preserve them. The mind may even appear to have forgotten the order of movements, but so strong is the power of mental association that we have only to begin the performance to have all our slumbering ideas awakened, and each movement suggests the next that is to follow. We think, then, that the action is not of the reflex involuntary nature alleged, but that the apparent absence of mental effort is only apparent. Our reasons for holding this opinion are these. Pure reflex action is sudden and unregulated, both in force and duration; voluntary movements are strikingly the reverse of this, they are timed and regulated. The mind not only prescribes the nature of the task, but it directs the details of its execution, and at will shifts and varies these, either according to caprice or according to the necessities of external circumstance.

In no circumstances are we mere automatic machines, in which the cerebral lobes, having once acquired the habit of moving in a particular way, go on irrespective of the dictation of the mind. On the contrary, we believe that without the mind's direction no such movements as we have alluded to would be possible. In walking along a perfectly level road the length of our steps and the force accompanying each of them continue unaltered, and it is doubtless not easy to prove that each step is strictly dependent on volition. Let us, however, change our road, and suppose that we are walking rapidly through a rough highland glen, encumbered with loose *débris*,

and ploughed up every here and there by mountain streams; let us also suppose that we are at the same time engaged in discussion with a companion. In such circumstances we must all have remarked how pleasantly we are absorbed in the general energizing, mental and physical, which possesses us, and how unconscious we are of the details by which our very different actions are performed—the placing of the feet to avoid stones and ruts, the equipoise of the body, the play of the lips, tongue, throat, and lungs in moulding words. Yet it is very clear, when we reflect, that for each of these acts special muscles have to be called into action; the amount of nervous energy has to be calculated, and this has to be varied and adjusted to suit the nature of the spot on which we decide to plant the foot; and on many unforeseen objects and obstacles which start up in our path. And all this time, let it be remembered, the mind is engaged in conducting a reasoning process, searching for arguments and illustrations, and suitable words to embody them. If it is held that the mind is not the agent engaged in directing the details of the pedestrian part of the performance, then, with equal show of truth, may it be maintained that it has no part in directing the more intellectual process we have described. Were we called to determine which of the complex operations were most engrossing, it would be very difficult to do so, Each of them was apparently conducted with ease and enjoyment, and flowed on without sensible effort, yet each required an exercise of intelligence. Did the mind, we ask, by quick alternate efforts prompt each individual act, or is the mind Argus-eyed and capable of seeing and directing many separate concerns at once? Of this we can say nothing with certainty. One thing at least every person must have observed in a case such as that stated, viz. that from time to time, one fact or another, connected with the very dissimilar work which engages us, presents itself for settlement—it may be regarding a difficult step, or regarding the selection of a proper word or illustration; and such salient points remain in

the mind for a time, longer or shorter, and by doing so they serve to prove that the mind is really working on the matters before it, though it is not *retaining consciousness* of the separate steps of its proceeding.

We may well inquire how it happens that we are apparently unconscious of details which imply even strenuous mental action. To answer this we must remember that the faculties of man and of all animals are eminently practical in their method of working. Thus, while we can see and consider many separate objects at once, or at least with a rapidity of apprehension resembling simultaneous action, the mind only retains what it is important to retain, namely, the main or ultimate object which it is striving to realize. The mind and the eye work in wonderful sympathy; they glance with lightning speed from one object to another, and they can take instant action, unless the circumstances which emerge are entirely strange. In walking, talking, and reasoning, then, there is, we think, a sustained action of the mind with reference to each of the operations; but as it is not desirable that the details should cumber the memory, these pass across like shadows, and leave no trace. Were it not so, we would never get out of the wood; the mind would cease to be an efficient, superintending, reasoning principle, planning and striving after new objects; it would become a mere receptacle of used-up facts, and a cloud of infinitely small and infinitely numerous atomic objects and atomic ideas would obliterate all clear and extended aims. As our faculties then are limited, and we cannot grasp the *all*, we are so constituted, that while we work necessarily among details, we work for results, and we keep the latter only in the mind's eye. Just as our bodies, and all things, are composed of atomic parts, yet these are only apprehended in the concrete when compacted into objects of use, so it is with that which constitutes the substance of our thoughts and actions—the aim is kept before us, the steps which lead to it are cast aside so soon as they are used, and they drop out of view, the larger portion never by any effort to be recalled.

To illustrate this seeming inattention to external impressions when the mind is occupied with another pursuit, nearly every one must have observed that when a time-piece is placed in a sitting-room, it may strike the hours and half-hours in the most ringing tones, and yet, in an incredibly short period of time—say a few seconds—we are unconscious of the event having occurred. The lapse of a short but notable interval, we think, is requisite to produce the entire obliteration of the mental impression; at least, this is our experience. We would say about four seconds may be required for erasing the impression of twelve strokes of the hammer; and we think that less may frequently serve for erasing a less continued impulse. If the attention is immediately called to the circumstance of the clock having struck, we think most persons will be conscious of the last stroke as of a sound still mixing with the other thoughts which occupied the mind.

In vindicating mental agency in opposition to the machine theory, we are far from denying that the whole animal organism, and especially the nervous system, is framed like a machine for effecting the work it has to do with the least possible exercise of mental effort. We have seen that the heart beats and the lungs perform their movements by virtue of the ganglionic nervous system, unassisted by volition. We can then readily believe that the spinal column, the medulla oblongata, and the sensory ganglia, are the centres whence emanate directly the nervous energy which moves the limbs. But in every living animal we believe that the application of the appropriate mental act or effort is essential, not only to regulate, but also to sustain the nerve force, which otherwise would soon cease to act. For though after repose and good feeding the nerve tension is often at very high pressure, and ready to discharge itself spontaneously in many ways, yet life and labour are generally felt to involve both serious and exhausting exertion, and we know that without strenuous mental effort in sustaining labour, bread is seldom earned in

this world. When an animal has been recently deprived of life, we know that the limbs may be readily thrown into convulsive action by the application of chemical, galvanic, or mechanical irritation. This marks the admirable adaptation of these organisms to the purposes of animal life ; but we know equally well, that all measured movements cease the moment a musket ball passes through the cerebrum ; and reason teaches us that such actions could never be conducted without the exercise of the judging and controlling faculty.

We shall here state more in detail the matter as it appears to us.

First. When any one has brought himself into a state of preparation for an immediate and sustained bodily action, especially if it is of a kind to tax the strength, such as running, leaping, wrestling, lifting a heavy weight, or the like, those parts of the muscular and nervous system which are to be engaged are, by this inchoate mental state of preparedness, or excitement, raised to a corresponding condition of nervous tension. We have only to observe the irrepressible nervous excitement of mettlesome horses just before the slackened reins permits them to start. Their pent-up power and nervous restlessness originate from the mental excitement, or preparedness, of which we speak. In all animals of calm temperament this nervous tension corresponds, in measure, with the amount of the physical effort about to be made, and there is no waste of power.

Second. The muscles and the cerebral organs, when thus prepared, are rendered peculiarly susceptible to every stimulus, whether mental, such as the volitional act, or physical, such as the external impression makes on the afferent nerves. Every one must have observed how easily reflex actions are at such times excited : a touch, for instance, of the hand makes the party give an involuntary movement.

Third. The body and brain being thus prepared by the previous mental state, when the task to be performed is begun, we believe that the mind, not only controls and

regulates the nervous energy, and directs it to the appropriate cerebral organs, whence it passes to the muscles, but that it also exerts the power with which it is endowed, in producing the discharge of nerve force from the cerebral substance. This action or effort of the mind becomes very observable during severe or long-sustained bodily exertion. We do not see that the explanation is at all simplified by assuming, as Dr. Carpenter does, that the mind delegates the details of the work to the sensory ganglia, while itself is entirely ignorant of these details.

Fourth. The action of the afferent nerves, and the perception of the muscular sensations, which accompany all muscular movement, are of special service in more ways than one; thus, first, they inform us that the movements of the limbs have been accomplished; and, second, they afford us a ready index to the amount of force exerted by the limbs, and of resistance overcome, whether the task be lifting a weight, leaping a wall, or guiding a pen. And, third, these muscular sensations of which we are conscious also serve to keep before the mind, and, as in walking, to suggest the repetition of the action which is to follow.

Fifth. In the act of walking then, while these muscular sensations proceeding from the limbs afford intimation that the feet have been planted on the ground, and so suggest to the mind its next act, they doubtless also act on the appropriate ganglion as a stimulus which materially assists in keeping up the necessary brain tension. The result of these two efforts—the mental sensation and the excitement of the nerve centres—joined with the physiological tendency which we have reason to believe exists in the cerebral apparatus, namely, the tendency to repeat, in regular succession, any series of acts once acquired—all these, when regulated and sustained by the active powers of the mind, concur in producing the result of a smooth and rhythmical movement in walking.

We must see clearly that the spasmodic action of the limbs, which reflex action produces when uncontrolled by the

will, is essentially different from voluntary action. For, first, reflex action is convulsive, or by a jerk. Second, it is sudden or immediate, the movement of the limb following instantly the excitement of the afferent nerves. In walking, the action in no respect agrees with this: there is neither a convulsive nor an immediate action of the leg. In walking, when we have planted one foot on the ground, we, for a sensible period of time, balance the body on it; and at the same time we call into action, not the same, but a new set of muscles, with a view of advancing the other foot; and it is not till that other foot is on the ground, and the weight of the body is thrown on it, that we, in a deliberate manner, lift the hindermost foot and advance it to repeat the action. It is very evident that without this timing and adjusting, no walking could be accomplished; we would have nothing but convulsive actions, such as are witnessed during epileptic fits, or such as we see when a decapitated frog has its toe pinched.

Sixth. There remains another and an equally curious question connected with the subject of voluntary motion; namely, how do we acquire that ready command of the limbs which we possess? and how do we learn to determine the proper nerve and the proper muscle to be used? It has been proved that all consciousness and all mental action are confined to the region of the brain. The nerves are merely the media of communication between the body and the cerebral organ for the purposes of sensation and voluntary motion. In the brain, or at least in certain parts of it, are centralised the entire government of the body, so far as voluntary motion is concerned. The mind, however, it would seem, remains always ignorant of its immediate physical surroundings; it knows nothing of the cerebral organs by which it is affected through external impulses, neither does it know of those cerebral organs by which it accomplishes its motor efforts. If the mind, then, is so entirely ignorant of its own physical organs, the inquiry is all the more curious, how it so soon acquires through them an easy and perfect mastery of the body?

To enable us to examine these subjects, let us consider our faculties, not in their maturity, when the difficulties of locomotion have been overcome, but in infancy, when we are in the course of acquiring the use of them. A child knows not the mental act necessary to move any particular limb; indeed, we may confidently assert, it knows not that it possesses limbs till it has got experience of the fact from the various sensations which flow into the mind from the different parts of its organism.

Under pain, joy, or excitement of any kind, the child's movements are indiscriminate and spasmodic, consequent on general cerebral action caused by the emotion.

The first muscles which a child learns to use systematically, or of purpose, are probably those connected with suction and deglutition. Now observe that the muscular action thus aroused, in return produces those pleasing sensations which accompany the acts. The motions of sucking and swallowing, and the relative sensations, will thus be, to a great extent, dependent the one on the other. We may suppose the actions in the first instance to have been purely of a reflex nature; they will, however, very soon become voluntary acts, for the mind will not remain long passive, but, prompted by the sensations, it will strive to increase the movements as a means of increasing the pleasurable sensations.

It would seem, then, likely that to acquire the power of voluntarily acting on any particular muscle, and of thereby moving a limb, we must first have experience of impulses and sensations from that limb to the appropriate cerebral lobe. The first sensations may arise from natural cravings, from external contact, from accidental or from reflex movements, or solely from an exuberance of nerve force and consequent spasmodic action; but, as we have said, the self-same cerebral lobe which is acted on by the sensational impulse coming from any limb, is generally instrumental in producing the movement of that limb. This is more than a supposition, for it is in accordance with the general law of reflex action, and

the knowledge of this law enables us to see how the sensations may serve as guides in directing the mind to its action on the part of the brain required to produce the desired movement.

We can easily see also that the mind, having once become conscious of the connection between the specific mental act, and the physical consequent, the two become inseparably associated, and that the command we acquire over the entire body may be only an extended experience of this kind. True, we know nothing of the cerebral organs, we are only conscious of the *effort to move the limbs.* This, however, is in strict analogy with all we know of mental action. The mind, though it acts directly on the cerebral mechanism, with which it is directly connected, yet is only conscious of its acts as these have reference to the external results.

From what we have said of the helping and guiding influence of the sensations, and the tendency to reflex action, we would not have it supposed for a moment that in locomotion the mind has little work to perform beyond its restraining and directing duties. This we believe to be very far short of the case. Certain external stimulants may produce reflex action by the discharge of nerve force from the spinal cord, medulla oblongata, or any of the lobes at the base of the brain ; but for all regulated and sustained voluntary action, the mind, besides possessing the direction of the movements, acts as the chief moving power, by liberating from the brain the larger portion, as we believe, of that nervous energy, or motor power, which, directly or indirectly, causes muscular contraction ; but of this we shall speak in a later chapter.

NOTE.—Since this chapter was in print the author has had an opportunity of perusing the very instructive address of Professor Huxley at the British Association at Belfast, in August, 1874, "On the Hypothesis that Animals are Automata" (*Nature*, 1874). To determine how far man and other animals are machines in the movement of their limbs, is one of the most curious and interesting questions of the day.

Experiments made on frogs by the removal of the fore part of the cerebral hemispheres, have proved that these animals when so mutilated still possess the power of preserving themselves from slipping off from an inclined surface, by employing all the necessary complex movements of their limbs.

The difficulty in such experiments is to ascertain whether there is consciousness or not, and whether the movement is voluntary or not. Till we know better the functions of the different parts of the brain, we cannot say what extent of mutilation is necessary to produce entire unconsciousness and loss of voluntarv power.

In sleep the mind is often active; and to a certain extent we are conscious of hearing and touch though we cannot discriminate nicely; still less can we exercise voluntary motion. Somnambulism is still more curious, for here we are apparently unconscious by sight, and yet the patient generally walks and avoids contact with obstructions. Few, we imagine, would say that when in this state the party was acting as a mere machine. The movements may possibly appear to Professor Huxley purely automatic, to us they appear voluntary, and the mind seems actively directing them.

The author is willing to admit that he naturally inclines to defend—he does not say to extend—the influence of mind both in man and in brute. It is possible that from the nature of Professor Huxley's studies he may tend naturally in the opposite direction, and experience a peculiar pleasure in showing the perfection of the animal machine which he has so long and so successfully studied. Truth is the great aim, and sometimes it is not easily obtained.

PART V.

CRITICAL SKETCH OF SOME LEADING PHILOSOPHICAL OPINIONS AND SPECULATIONS.

CHAPTER XXIX.

INTRODUCTORY REMARKS.

PLATO.

IN accordance with the arrangement of the subject which the writer has prescribed, he has now in this Fifth Part, and also in the Sixth or concluding Part of the volume, to endeavour to make a practical application, in the cause of philosophy, of the facts and principles contained in the preceding chapters. This is one of the chief objects he has throughout had in view.

It may be asked by the reader, Do you intend to direct us to philosophy or to physics, to science or to metaphysics? To this we reply, that our wish is to examine the relation which subsists between the human mind and the physical world. In other words, we desire, as best we can, to give the facts of science, in this connection, a philosophical application.

The great difficulty is ever to raise the reader above his ordinary apprehensions of things, and to create an interest and a belief which, possibly, up to the time have not been experienced. Comparatively few men have formed for themselves any opinions either in religion or in philosophy. It may either be that they have not naturally much of an inquisitive spirit, or it may be that the drudgeries of life have deadened down those questionings which stirred within them in their earlier years. With regard to religion, they are therefore content to accept the teaching of the pulpit and of the school, as if the subject were not a matter to be inquired into by ordinary men. And with regard to philosophy, the vast majority even of the educated classes ignore it altogether. They either imagine its problems to have been already

worked out, or they suppose it to be something destined to remain for ever unsettled, and therefore wisely to be shunned by men who, in carrying on the business of the world, have, as they imagine, much more important transactions on hand.

There is some show of excuse, we admit, for this apathy; for though it is admitted that among the votaries of philosophy there have been in all ages names of the very highest mark; and though mankind is disposed to accord a willing homage to those who, in different stages of the world's progress, have striven to advance human knowledge; yet, mixed with this reverence, it can scarcely be denied there lurks a strong feeling of doubt and distrust, if not of the men, at least of the subject, which has yielded such various and contradictory results. To such objections the usual reply is, that in high and difficult attempts it is honourable even to fail. This is in truth a most inglorious defence of a glorious and holy cause. We ask the reader if it is not one of man's most important duties to set himself to know something of the mystery which meets every one who inquires earnestly into the nature of this great cosmical system amidst which he is placed? and we ask, moreover, whether or no the act of grappling for a time with such questions, whereby, once for all, a man may learn, practically and convincingly, the limits of the human faculties, is not in itself one of the most important exercises of the human mind?

The present attempt does not aim after anything at all transcendental, or even strictly metaphysical; it takes a much humbler course, but it leads nevertheless to the highest conclusions. Science has been quietly advancing our knowledge in various directions; and many broad and important principles have been established, which seem to make physics approach much nearer philosophy than it did in the days of Plato, or even in the times immediately preceding those in which we live, when the laws of mind were in our country so worthily treated. It seems, then, to the writer that we are in a position in which the endeavour to

represent the subject of the senses in an aspect where science and philosophy are strictly conjoined, may be safely ventured upon. The author has been the more disposed to make this attempt from seeing that, in our day, philosophy stands some risk, either of running into a subtle idealism, or of becoming extinguished under the rude shock of a meagre but presumptuous materialism. But, all other reasons apart, in the defence of philosophy we will maintain that it is good for all men, at times, to raise themselves above earthly pursuits and cares, to climb the higher peaks, to breathe a purer air, to see the world stretched beneath, and all its petty ups and downs reduced to a minimum. Another advantage from the study of such subjects is this, we have evidence that even the purest faith in the hands of an ill-educated or ambitious priesthood may lose its divine character, and may be so contracted and distorted as to drag the people down with it to almost any stage of unquestioning submission and debasement. The benefit, then, of a healthy and elevating tone of literature and philosophy, as a preservative, cannot be over-estimated. A philosophy which will lead men to think, cannot fail to act beneficially both on the teachers and the taught. Let us not, then, undervalue its importance. If philosophy, even though it may seem to the utilitarian to yield but scanty fruits, yet helps to encourage independent and reverent thought, it does a great work, and should not be held in low esteem.

Realistic philosophy regards man as a spiritually endowed being, invested with an organised body. It finds him inhabiting one of the smaller masses of a physical system, to whose extreme bounds the finest telescopes cannot pierce. One of the chief and prominent aims of such a philosophy is to inquire into the nature of the connection which man holds with his physical surroundings. To do this effectually it is evident we must not restrict ourselves to the mere study of mind, as has been too much the practice of those mental philosophers who in our country have treated of the subject.

This practice, which originated, no doubt, in a horror of materialism, has stood much in the way of our progress in scientific philosophy. It originates from an entire misapprehension; for it is evident that if we believe in a one Cause of all things, it follows that all the departments of nature will be co-relative, and each one will throw light upon the other—all will be found to be parts of a one great system, contrived, connected, and adjusted for special purposes, as befits the work of a one designing Mind. Nay, it will be found that the more minutely we examine nature with reference to her physical laws, the more intelligible will the nature of their adaptation to the purposes of the mind become; and, indeed, if properly interpreted, we shall find that these physical laws afford us a key to the true philosophy of the senses. If the writer had not this conviction, he would not now be venturing to present a theory of perception, if not founded on a new element, at least founded on an application of a principle never, so far as he knows, so used, and which application seems to him at once to remove the difficulties which have, since the days of Descartes, hung over the subject, and perplexed the minds of mental philosophers. We refer to the subject of the connection of mind with matter.

It were easy for a writer to state simply his own opinions, but merely to do so would, perhaps, not be eminently instructive. It is better in such a subject that the reader should be led to arrive at opinions and judgments of his own by the previous exercise of his critical faculties on the doctrines and theories of others. We believe that substantial benefit is to be derived even from a cursory examination of those looser speculations and reasonings which exercised the world in early times. The subtle Grecian mind, it cannot be denied, sowed the early seed of thought, and scattered those germs which still retain their vitality, and which have fructified over the civilised world into questions of never-dying interest and importance.

Impressed with this conviction, the writer had prepared

a brief, and it might justly be called a slight, sketch of philosophical opinions from the days of Thales down to modern times; but feeling averse to swell the bulk of his volume, and knowing that the subject was accessible to the inquirer in various well-known works, he cast his sketch aside, merely selecting from what he had thus very hurriedly written, such chapters as treated of men whose views seemed more closely allied with different phases of modern thought. As the writer deals chiefly with points which concern the special subject of the senses, he need scarcely say that nothing but a very cursory examination of the writers here to be named is attempted.

PLATO.

How gladly would we give some intelligible sketch of this great representative of Grecian thought and speculative philosophy; but how can he, whose writings filled so many volumes, and whose discussions have exercised the human mind for more than twenty-two centuries, be condensed within a few pages. Doubtless it was said with reference to writings still more important than those of Plato, that on two short precepts, deducible from them, hung all the law and the prophets. And it may be asked by those who have not acquainted themselves with the great Grecian thinker, Can the gist of his philosophy not in like manner be abridged? Perhaps with no writer in the world is abridgment more impossible than with Plato. The Hebrew writings to which we have referred were in the main practical; the writings of the Grecian sage are largely argumentative, imaginative, and theoretical—the former were addressed to the heart of the many, the latter are addressed to the head and the fancy of the intellectual few. We eat bread for nourishment, but we sail on the Nile and the Amazon, not because of the purity and wholesomeness of their waters, but for knowledge, for enjoyment, from lustihood and the love of what is great and difficult and perilous, and because those

broad streams carry us through regions whose scenes will furnish us with pictures and problems for a life-long retrospection. Plato can as little be presented in miniature as the scenes on the banks of these rivers can be understood by description. It is fortunate that such copious writings, dealing largely with subtleties, the meaning and import of which can now with difficulty be understood, and thus taxing severely both the patience and the logical abilities of his readers, are yet wonderfully relieved by the life and dramatic power with which most of them are instinct. His illustrations are graphic and picturesque, and sometimes broad and grotesque, this gives a living interest and spirit of reality, equal to what we feel in reading the "Pilgrim's Progress," the "Anatomy of Melancholy," or the "Arabian Nights' Entertainments." The most startling speculations are thrown out with the completeness and freedom of one who had been behind the curtain and had seen things invisible.

Plato was born at Athens about 427 years before Christ. His youthful mind was impressed, if not oppressed, by the evils and disasters consequent on the Peloponnesian war, at the same time that it was gathering in all the better influences which prevailed during that short but brilliant spring-time of Athenian literature and genius. As became a youth of his rank, he studied gymnastics, music, poetry, and philosophy. When twenty years of age he became the reverential pupil of Socrates. After the death of his master—whom, it is said, he had, on his trial, undertaken to defend, but was interrupted and silenced by the judges—he went in his fortieth year to Megara in Sicily, to visit Euclid, and afterwards, it is said, to Egypt, Persia, and Syria. By these travels, which extended over thirteen years, he may be supposed to have enriched his mind, culling from the ethics and philosophies of these nations, and especially from the schools of the Eleatics and Pythagoreans, and, it is believed by some, also from the Hebrews, whatever commended itself as truthful, beautiful, mystical, or sublime.

Plato after this occupied a small house and garden near the sacred precincts of Hecademus, about a mile from Athens. It was here that in mature life he founded that school of philosophy which was destined to be so famous throughout all time. Here, in dignity and consideration, he spent the remainder of a long and honoured life, discoursing to his disciples, and framing those wonderful dialogues which not only powerfully influenced the thought of his own times, but which have from that distant period to the present more or less reflected the thoughts of mankind, and which are, accordingly, being still translated into the languages of modern Europe. Plato died at Athens, having attained the age of eighty-two.

It were a mistake to conceive that Plato held firmly all the positions which we find him supporting by ingenious argument in his dialogues, for then must he have believed many inscrutable mysteries, if not also many contradictions. There is no author who turned over so large a mass of insoluble metaphysical questions. His life was spent in spiritual gymnastics, and his honourable mission was to infuse, along with a pure morality, a living interest in many of the most important and profound questions, and to transmit them to posterity, as material calculated to maintain intellectual life, during periods when the pulse of public virtue and political honesty beat low, and when the world, but for the elevating tone of the writings of this great thinker and moralist, must certainly have lapsed into a still deeper dullness and debasement.

The pictures which Plato draws have such an air of reality that they never fade from the memory. We all know some of them. How readily do we realize his description of the birth of the human soul in a pre-existing heavenly state, and the doctrine of the metempsychosis. We may not be able to decide whether he means us to accept his language as given in sober earnest, or as merely allegorically intended, but either way how willingly do we yield ourselves to

his attractive beguilements. Human souls he describes as being born in heaven, and as carried through the lofty celestial circles in the train of the gods, surveying along with them the region of *real existence*, beholding the archetypal originals of those things of which we in this lower world perceive only the dim and unsubstantial shadows—Goodness, Temperance, Wisdom, Beauty, Truth, all in their pure and august aspect, as self-existing realities.[1]

Some of these human souls, however, either from possessing a taint of earthliness, or from a want of due aspiration, are represented as sinking down gradually to the level of the earth, and being thus brought into connection with the physical state. This earthly relation they for a lengthened period of time are doomed to endure, and to be subjected to the trials and probations inseparable from such a connection. They, however, who conduct themselves justly and worthily, are on death raised to a higher earthly position, and after passing through various gradations are at length restored to their original heavenly state. Souls, on the contrary, which have abused the earthly connection, are made to descend still lower in the scale, and to animate the bodies of a succession of inferior animals.

The few souls who apply themselves to the contemplation not of the shadowy appearance of earthly things, but to the discovery of *the real*, striving thus after the restoration of those ideas which they possessed in their previous heavenly state. These heaven-born souls, after a shorter earthly probation, are again restored to the celestial mansions congenial to the cravings of their higher nature. (Plato's Phædrus).

Much of Plato's peculiar philosophical opinions may be discovered in this parable. Thus, it is in accordance with his doctrine of innate ideas, and it was indeed intended to

[1] It is interesting to remark how truly Platonic is the language of the great Hebrew philosopher when talking of wisdom—how he embodies the abstract in the concrete: "Wisdom hath builded her house, she hath hewn her seven pillars. Before the mountains were settled, before the hills was I brought forth. When he prepared the heavens, I was there."

explain their existence. For Plato regarded the fundamental judgments of human reason, not as the results of the exercise of that faculty applied to the discovery of truth, but as a reminiscence, or recalling, of the facts of knowledge possessed in the previous state of being.

Again, from this parable, as elsewhere, we observe that the *real world* of Plato was the world of *ideas*, and not the world of sense. The impressions of the senses, and the shifting objects they reveal to us, he found it impossible to explain; and though he did not, like the Eleatic philosophers, consider them as entirely deceptive and illusory, yet he so expresses himself that it is impossible to determine the exact light in which he regarded the material world. Our phenomenal world, and the real world of ideas, are discussed in contrast under various titles, in his different dialogues; thus, as the ONE and the MANY; as BEING, and NON-BEING; the WORLD OF REASON, and the WORLD OF OPINION; the INTELLIGIBLE WORLD, and the UNINTELLIGIBLE WORLD; the WORLD OF REALITIES, and the WORLD OF SHADOWS.

No picture given us by Plato is better known than that in which, in the Dialogue on the Republic, he illustrates the nature of our sensuous knowledge under the similitude of captives confined to a darkened cave. We shall give it as it is elegantly rendered by Ferrier ("Phil. Remains"), after which we shall say a few words upon Plato's world of shadows and world of realities. Suppose, says he, a lot of men in a subterraneous cave, which opens to the day by a long straight passage, and that they have been kept in this cavern from childhood, fastened so that they can only look towards the bottom of the cave; and that across the mouth of the cave pass men and other figures, some silent, some talking, these captives exactly represent the condition of us men, who see nothing but the shadows of realities. These captives, in talking with one another, would give names to the shadows as if they were realities, and when the passers-by spoke they would imagine, of course, that the shadows

spoke. And, in short, in every way they would be led to think that there were no realities except these shadows.

Now consider how these captives might be freed from these illusions. If one of them were loosed from his bonds, and made to turn round and walk towards the light, and fairly brought out into the light of the sun, he would at first be so blinded as not to be able to see things in daylight. At length he would be able to look at objects, and even at the sun, and to find that he regulates seasons and years, and is in a certain sense the cause of all the things which they in their captivity saw. And when he remembered his old habitation, and the wisdom of the Den and his fellow-captives, do you not suppose that he would felicitate himself on the change, and pity them. Now this image is to be applied to the case we were speaking of. We must liken the visible world to the dark cave, the ascent upwards, and the vision of the objects there, to the advance of the mind into the INTELLIGIBLE WORLD.

They to whom the science which treats of the nature of sense perception is new may well ask, What does all this mean? What does Plato intend by so constantly contrasting the world of sensations with the world of reason, the world of shadows with the world of reality, the intelligible world with the meaningless and unintelligible world of phenomena. Let us, without pretending to know his precise meaning in all particulars, endeavour to show how far Plato is justified in employing such language, and in what respects he is fanciful.

That man walks in a vain show has been alleged by moralists in all ages, and that he follows shadows, thinking them substance. Can the chief objects of man's ambition be said to be real and substantial—honour, riches, titles, stars and garters, a name, posthumous fame, and such like? Man perils his life and soul for these, as if they were the only realities, and he dies striving to realise them, or having realised, to retain them in his grasp.

When we turn from moral considerations, it is undeniable

that we have no absolutely true knowledge of the physical world in which we live—certain external agencies excite within us a variety of pleasing or unpleasing sensations. And what are these sensations in themselves but arbitrary, unmeaning signs or symbols. If we speak of intelligence or knowledge, these signs, in themselves, communicate no more information to the man or to the child than the letters of the Persian alphabet. We acquire the habit of regarding them as properties existing in the external world, but in so doing we are deceiving ourselves—the sensations are subjective feelings and not outward realities. If they were external realities, we could describe them as such, but this we cannot do, for they belong not to the physical world at all; they belong to the mind; they are given to us short-sighted beings, not to afford us an intuition into the mystery of nature's being, but merely, at least primarily, to enable us to guide our steps through life.

If we ever come to know more than the sensations give us, it is, as Plato tells us, by the exercise of a higher faculty than that of the senses. In the physical world there is neither light, nor heat, nor sound, nor taste, nor smell, nor any of the sensations of touch, which constitute so large a portion of our enjoyments. These phenomena, no doubt, are the result of energy acting in particular ways, and addressing itself ultimately to the mind, but what enters the mind bears no resemblance to the external realities. The forms only of external objects are given us by vision.

The world is thus to us a mere world of sensations and shadows, quite as unlike the realities as Plato declares them to be. He was right, then, it would seem, in saying that we walk under the delusions of a world of sensations, unable to see that which underlies the phenomena, guessing only at what it may be and how caused. We are much in the position of the captives in the cave; for we imagine that the impressions which are within us are realities spread around us in the world.

Plato knew little of the laws of nature as we now know them; he saw, however, that our sensations were meaningless and illusory, and he imagined that they possessed just enough of resemblance to awake in the mind the reminiscence of the heavenly realities. He believed that reason, by forming abstract conceptions of these meaningless phenomena, might realise their true existence, and thus construct an intelligible world. It was, no doubt, a strange perversion, or indulgence of thought, to view abstract ideas of earthly things, such as mountains, and trees, and rivers, and chairs, and tables, as the real things, but it was a notion peculiar to his day; and it is observable that the mind which possesses little knowledge of the minutiæ of physical science, floats all the more readily into idealism. The same idea is expressed in a somewhat different manner, when in another place he says that earthly things are formed after the idea, or pattern, formed in the mind of God. Now on this we can at least admit that though the *Idea*, or pattern, of a chair or table does not exist in heaven as a reality in Plato's light, yet the chair and table are made by means of the idea, or purpose, in the mind of the maker; and the mind of the maker is not an earthly thing, but a spiritual or heavenly thing. And in the same way regarding the creating of man and the inferior animals, are these, we ask, and their functions not previously in the infinite Mind? He that formed man's mind, shall He not understand!

These Platonic views, it will doubtless occur to the reader, may without any great strain be translated into modern thought; and when this is done they become to us both truthful and sublime. We need not picture heaven to be stored with the original patterns of all earthly things, past and future, but we use language in strange accordance when we say that the world is fashioned after the plans and purposes of the great designing Mind.

Plato recognises three distinct aspects of the world. First, the unintelligible world of sensation; second, the world of

opinion; and, third, the world of knowledge—of ideas—of reason. How much truth there is in this division will become apparent when we properly examine it. Thus, in perception there are, first, the sensations, the *æsthetic* of Kant. These, as we have said, are given to the mind as the result of physical impressions, and in receiving them the mind is merely passive or receptive. We may imagine the lowest class of animals endowed with this extent of consciousness, and that with them perception goes no further. With man and the higher animals it is very different; instantly that the sensations are experienced, the mind applies its active energies, and forms judgments regarding them. In vision, for instance, it contemplates the sensations with reference to the sizes, forms, and arrangements as given; it combines them, and declares the whole a *unity*, an object of perception. This is accomplished by an act of intelligence, or judgment, and without this faculty perception proper were impossible. This is Plato's world of opinion. Then, third, there is the world of knowledge, which is acquired by the contemplation of what is not seen. This is entered upon by virtue of a still higher faculty of the mind; by which it instantly postulates an adequate *cause* for what exists. It concludes the phenomenon to be caused, by matter, by spirit, by an adequate power of some kind. On entering still more deeply into the subject, it forms the idea of Deity as the one intelligent cause, and the sustaining substratum of the world and of all sensible objects.

Let us here, then, vindicate Plato in his philosophic views. It is undoubtedly correct to hold that we never *know the real world* unless we form a correct judgment of what it is. If we theorise incorrectly, and suppose, as most illiterate persons do, that the world possesses the properties of our sensations, it is evident that we live under a delusion regarding it. If, on the other hand, like many modern philosophers, we conceive the physical world to be merely ideal, or existing in the mind, and not extended in space; or if we assume it to be material,

as so many do, or as dynamical, as is done by others, it is evident that these various views cannot be one and all true; and therefore, as perception is a judgment formed by the mind on the sensations presented to it, it is evident that we can only have a *true perception* of the world when we form a *true conception* or judgment of it; or, to employ the language of Plato, we only know the true world when we perceive the real ideas of it.

From this the reader will be able to form some notion of the subtlety of the Grecian mind at these early times.

CHAPTER XXX.

SUCCEEDING SCHOOLS.

NEO-PLATONISM—PHILO—PLOTINUS—PROCLUS—PATRISTIC AND SCHOLASTIC PHILOSOPHY.

IT would be entirely out of place to trace here the history of Platonic philosophy downwards through the ages. We should, however, feel it unnatural were we coldly to drop so large and important a subject without making some few remarks.

The philosophy of Plato and Aristotle, it is well known, greatly influenced the mind of the civilized world for eighteen centuries. The reflection on which remarkable fact is not without alloy; for the moralist may well regret that the authority of these two great schools should so far have overmastered the human intellect as to have, for a long period, almost entirely arrested original thought and free inquiry. In the sixteenth century, however, the influence of the Reformation, and the rise of modern philosophy, awoke in the world a new and a more questioning spirit.

The philosophy of the two rival Athenian schools contained so many points of agreement that it became a chief effort of the learned of succeeding ages to reconcile apparent differences, and to consolidate the whole into a reliable system. The effort seemed satisfactory, no doubt, to those engaged in it, but how illusory much of the success was, and especially in physics, we now well know.

The Academy and the Lyceum lost their transcendant lustre after the death of their great masters, Plato and Aristotle. The Middle and the New Academy, no doubt, under Arceselaus (b. B.C. 316), and Carneades (b. B.C. 213), long possessed considerable influence, chiefly exerted in the dis-

cussion of what we must regard as unprofitable subtleties. Let us leave then the Grecian schools, and say a word regarding the phases which Platonism assumed in a new region, and amidst other influences. The germs of this philosophy, wafted to Africa, took root in the large commercial and literary city of Alexandria, about 300 years after the death of Plato.

Philo, the Jew, born at Alexandria a few years before Christ, is recognised as the first Neo-platonist of this region. He had imbibed the philosophy of Plato chiefly as it was set forth by Carneades, in the New Academy at Athens. His chief object was to recommend the books of Moses to the cultivated Platonic mind of his fellow-citizens, by showing how the two systems might be reconciled, and how in many points they were in accordance. In this attempt Philo drew largely on his imagination, and, by ingeniously assigning symbolical meaning to nearly every important word and act recorded in the Pentateuch, he endeavoured to recommend these books to the philosophical pagan mind, especially as regarded the Trinity and the Logos. This new phasis of philosophy continued to enlist high names. It flourished in Alexandria for nearly four centuries, attaining its highest influence under Plotinus, born at Lycopolis, in Egypt, A.D. 204, and who died at Rome, A.D. 274; and under Proclus, who was born at Constantinople, A.D. 412, and who died at Athens, A.D. 485. These men, eminent in their day, endeavoured to frame a philosophy which might arrest and supersede Christianity; and at the time of the Emperor Julian, the Christian faith and this form of philosophical belief seemed, by outward appearances, as if trembling in an equal scale. The strong and simple religion of fact was, however, happily destined to triumph over the fanciful and elaborate and, as it had latterly become, highly mystical system of man's devising.

One of the prominent doctrines of this school, under Proclus, was that the finite mind cannot know the Infinite Being by the exercise of reason, but, being of the same spiritual essence as

God, it may know Him by losing the sense of its personality, and thereby acquiring an intuitional or ecstatic perception; and that through music, thought, and divine love or prayer, we may ascend till the soul becomes lost in the Infinite.

With Proclus, who survived till near the end of the fifth century, Neo-platonism may be said to have expired.

We cannot contemplate the demise of Platonic philosophy but with certain regretful human feelings due to a system which lasted nigh seven hundred years, and which was so august in its original character and objects. Man advances ever slowly towards truth, and in all ages, and our own is certainly not excepted, we are doomed to witness much mistaken toil and many blunders before the direct road either in philosophy or religion is found, and even, after the passage is cleared, before man finds himself prepared to avail himself of it. A wise man will not then regard ancient philosophy, and all its interminable sophistical discussions on knowing, and being, on the nature of the soul, and on an infinity of other psychological questions, as either contemptible or useless. If it served in its day to elevate the pagan world above the more debasing forms of polytheism, and in many instances above material interests, passions, and ambitions, its influence is not to be contemned. To us, at this distance, it stands as the shadowy ruin of a once venerated structure, softening and refining the lines of the world's history, and showing that even in the heathen world man's mind recognized its imperishable nature, and strove ardently but unsuccessfully after a more perfect knowledge.

PATRISTIC AND SCHOLASTIC PHILOSOPHY.

ST. AUGUSTIN, ST. ANSELM, REALISM AND NOMINALISM, ABELARD AND HELOISE, OCCAM, ETC.

It forms no part of our plan, nor have we learning or ability to examine the character of the patristic and scholastic philosophy of the middle ages; but in order to avoid a total blank in the period between the decay of Neo-platonism and

the rise of modern philosophy in the seventeenth century, we shall endeavour to bridge the interval, in some measure, by pointing out certain of the names and events which stand out and give character to the period, availing ourselves of ordinary sources of information.

Many of the Fathers of the Church, says Tenneman, especially those of the Grecian Church, considered philosophy as in harmony with the Christian religion, or, at least, as partially so, inasmuch as they believed both to be derived from the same common source. Justin Martyr, for instance, affirmed that the *Logos*, previous to his incarnation, had revealed himself to the philosophers of antiquity. Clement of Alexandria enlarged on the same idea, and professed to consider pagan philosophy as an introduction to Christianity. To these may be added Athenagoras, of Athens, and Tatian the Syrian, the apologists of Christianity, who discovered, as they thought, many points of resemblance between the Christian religion and Platonism. Origen, for instance, the disciple of Clement, announced, in accordance with Neo-platonic views, that happiness consists in the intuition of the Deity.

"Philosophy," continues Tenneman, "was at first employed as an auxiliary to the Christian religion to assist in winning over the Greeks to whom it was addressed; subsequently, it was turned to the refutation of heresies; and, lastly, it was applied to the elucidation and distinct statement of the doctrines of the Church."

St. Augustin, one of the greatest luminaries of the Latin Church, was converted from an irregular life by St. Ambrose, at Milan, A.D. 387, and in the year 405 he was appointed Bishop of Hippo. He employed his philosophical acquirements, and his great and versatile powers, in reducing to system the doctrines of Christianity. And in prosecuting this aim he was led, says Tenneman, to a theory which, in many respects, appears associated with Platonism.

We shall now take a wide step across the dark and

unfruitful period which extended from this till the time of St. Anselm. Archbishop Anselm was born at Aosta, A.D. 1034; he became prior and abbot of the monastery of Bec, and died Archbishop of Canterbury, A.D. 1109. Anselm felt the want of a system of religious philosophy, and considered that it might be obtained by combining the results of the numerous controversies on such subjects, in accordance, for the most part, with the views of St. Augustin. With this object he composed his *Monologium sive Exemplum Meditandi de Ratione Fidei.* In this he endeavoured to develop systematically the great truths of religion. These attempts of St. Augustin and St. Anselm to systematise the doctrines of Christianity in accordance with reason, may be regarded as the foundations on which were afterwards constructed the tenets alike of the Romish and reformed churches. Here the historian and the philosopher will naturally inquire whether the habit which was so inveterate in these days, of metaphysically examining all questions, may not have prevented that broader and more sagacious interpretation of the principles of Christianity which would have ultimately formed, not only a sounder philosophy, but also a purer and more operative Christianity, with its foundations firmly laid on the declaration of Divine mercy and good-will, and the thence resulting fruits of purity, peace, humility, and love, as taught by its great founder.

About this time began what has been regarded as the longest, keenest, and most famous controversy which has ever agitated the intellectual world. And as it was practically a resuscitation of the old Platonic and Aristotelian question, regarding general or abstract ideas, it falls to be here considered as one of the natural products of Grecian philosophy. This question led to a division of the Catholic Church into two adverse sections, known under the famous party names of *Nominalists* and *Realists.* The former adhered to the views of the Stoics, and held that universals, genera, and species, and all abstract ideas, were not realities, but

mere names to mark the generalizations of the human mind. The Realists, on the other hand, held firmly by the views of Aristotle and Plato, maintaining that universals were eternal realities, existing either in the mind of God, or inherent in matter, and in the objects of sense. They held that there was a separate principle or energy, or *proton eidos*, which, belonging to every class of objects, belonged to all the individuals of the class, and which thus gives each individual its distinctive property. Thus, for example, fluidity, according to the Stagyrite, was that principle or entity which exists alike in water, oil, milk, and all other fluids, and which principle we contemplate when we employ the generic term fluid.

Apart from the mystical tendencies of Platonic philosophy, in which this view doubtless originated, all that we have to say in explanation of so strange a view is, that it is in some sort natural to believe in the existence of that of which we form a distinct conception, as, for example, of fluid, triangle, courage, man, ape, etc; and it is difficult to see how we can form a distinct conception of what has reference to externality, unless it really exists; and this is the position we are in when we employ generic names and entertain abstract ideas.

The question at issue had agitated the Alexandrian Church at a much earlier date; but it had been quieted down, though, it would seem, not entirely set at rest. At the time of which we now speak it was at all events revived in its original strength by John Roscelinus, who had called attention to a passage in Porphyry's Introduction to the "Organon of Aristotle." The substance of the passage represents Porphyry as stating "that he omits the intricate questions that were agitated about the nature of universals,"[1] such as whether genera and species do really exist in nature, or whether they are only conceptions of the human mind. If

[1] Porphyry was born, A.D. 233, at Batanea, in Syria. He settled in Rome, where he, a zealous expositor of Plotinus' views, endeavoured to reconcile them with those of Plato, Aristotle, and Pythagoras.

they exist in nature, whether they are corporeal or incorporeal, and whether they are inherent in the objects of sense or disjoined from them." These questions, Porphyry tells the reader, for "brevity's sake he omits, because they are very profound and require accurate discussion."

Roscelinus, in reviewing the discussion, and attacking the Aristotelian doctrine, by alleging that the notions of *genus* and *species* are mere words (*flatus vocis*), without meaning inflicted a wound on the orthodox faith which could not be allowed to pass.

The discussion derives its chief interest with the unlearned of our day from its connection with the romantic history of Abelard and Heloise—a history in which the talents and selfishness of the hero are only equalled by the generous, but blind self-devotion of the heroine.

In the controversy which we have alluded to, Abelard took a very prominent part on the Nominalists' side of the question, and from this the events of his painful and distressing history took their origin and tragic course.

Roscelinus' views were constantly opposed by the Church, as being considered inconsistent with the doctrine of the Trinity. In the fourteenth century, accordingly, the Nominalists had become nearly extinct, being reprobated by the orthodox generally, and especially by the disciples of Thomas Aquinas (born in Italy, A.D. 1224), and Duns Scotus (born in Northumberland, A.D. 1275). The cause of Nominalism was, however, destined to have another effort made in its behalf, and which was this time to prove successful. Wm. Occam, a native of England, had the honour of renewing the struggle which ultimately placed the views espoused by Roscelinus in their proper place. In effecting this, however, the war raged fiercer than ever, and much blood was shed. The Emperor Louis, of Bavaria, in gratitude to Occam for assisting him in his disputes with the Pope, sided with the Nominalists. Louis XI. of France, on the other hand, attached himself to the Realists, and, not satisfied with

lending the support of regal influence to a metaphysical question, he made his antagonists the objects of a continued and cruel persecution. (See Mosheim's Ecclesiastical History).

We have, perhaps, said more than enough on this question; but in closing our remarks on Platonic philosophy, and for greater clearness, we may be allowed a few words farther in explanation. Generalisation is the power by which we classify and group under a generic name and generic idea individual objects which have corresponding qualities. Thus, man, tree, nation, are generic terms; each embraces individuals which, by reason of some agreement, may be classed under the generic term. Without this power of the mind, and this use of generic words, language would be nothing but a repetition of meagre and unconnected facts and items; our ideas would, like particles of sand, be without cohesion or any human interest. The Peripatetic and Platonic notions were, that in every act of perception, and, moreover, in every thought, there must needs be some object that exists—something that is present to the mind, whether an idea, to use the language of Plato, or a phantasm, or species, in accordance with the language of Aristotle and his followers. What, then, it may be asked, is the immediate object which is present when the mind forms an abstract thought?—when we think, for instance, not of James or John, or of the tree in our garden, or of the twenty shillings in our pocket, but of *man*, *tree*, and the *number twenty?* According to Plato, these several generic or abstract ideas are not given us by sensation—they are not contained in any external object; neither, says he, do these conceptions originate purely from an act of the mind. They have an existence independent of the mind; they have an eternal, unchangeable existence in the mind of Deity, or in the presence of Deity; for Plato, at one time, uses the one form of explanation, and at another time the other. And, says he, it is only a shadowy conformity with the eternal and unchangeable idea that we perceive in the objects of sense in this world.

Aristotle was much less enthusiastic and imaginative than his master; and he expresses himself much more cautiously on the subject, by saying that all *individuals* are composed of *matter* and *form*, and that those different individuals which possess a common form belong to the same genus. He denied that these forms, or properties, or abstract ideas, were independent of matter, or could exist without it; and he thus seemingly expresses our views. The conception, however, which Aristotle had of *form*, was something very different from ours. He held in some accordance with Plato, that there were essential forms, or principles, or energies in all things, and that these were from eternity impressed on matter, and though latent in it were yet not of it. He held, moreover, that matter was ultimately, by these essential forms or properties, shaped into the objects we behold in the world. (See Stewart's "Philosophy of the Mind," Reid's "Intellectual Powers," etc.)

We now take a much more simple view of the matter than was taken by the great masters of thought in former times; but if we inquire nicely we shall find that a portion of the difficulty still remains unsettled, not only regarding the manner in which we form abstract ideas, but also regarding the precise object we have before the mind in the act of perception. What is it that the mind perceives? Is it the external object, or is it the corporeal affection, or is it the mental affection? Is it that the mind is affected through the agency of its organ, the brain, and is thus only conscious of the fact of its being affected with the mental phenomena? Which of all these describes the mental state which we call perception?

This we hope to consider in its proper place.

CHAPTER XXXI.

RISE OF MODERN PHILOSOPHY.

DESCARTES.

THE reader who turns to any history of philosophy will observe that the philosophy of the early Grecian sages was directed chiefly to things external. They speculated largely and ingeniously on the nature of the world and of matter, and on the nature and connection of God with these.

The philosophy of Plato and Aristotle was, again, much occupied with the metaphysical consideration of the objects of sense, and the nature of our perception of them.

This philosophy, as it was adopted by the Alexandrian school, underwent a refining and subtilising process, which brought it to a condition in the highest degree fanciful, artificial, and unintelligible.

The scholastic philosophy, again, which followed, starting with the reception of certain prescribed religious doctrines, endeavoured to shape these into a system of theological philosophy, which, like all philosophy in those days, was largely imbued with the leading principles of the later Platonists.

It is only those, who, in our days, can realise the state of entanglement to which the human mind had become subjected by these various influences, who will adequately apprehend the obligations which the modern world owes to such men as Francis Bacon and René Descartes.

Natural philosophy and the laws of physics, says Dr. Reid, had become fashioned into a system, in which, in the room of truth, science was content to wear the empty guise of learn-

ing, by assuming an almost unintelligible jargon of language in its place. Descartes felt the oppression and degradation, and he boldly undertook to overthrow it and to establish an entirely new theory of nature by starting anew with such simple and fundamental principles as could not be disputed.

In order to understand how much we owe to this sincere and independent champion of truth, let us consider the current opinions amidst which he lived. According to the Aristotelian philosophy of these times, all we observe in nature was considered a succession of the operations of generation and corruption. All natural objects are generated by the union of matter and form; regarding matter in its essence, *materia prima*, it is neither substance nor accident; it has no quality or property; it is nothing actually, but everything potentially; it has so strong an appetite for form that it is no sooner divested of one form than it is clothed with another, and it is equally susceptible of all forms successively, —such was the account of *matter*. Then as to *form*, which figures so much in Aristotelian philosophy. We are not to conceive it to consist in figure, size, arrangement, or motion,—these are indeed accidental forms,—but we are to understand that every production of nature has a substantial form which, joined to matter, makes it what it is. The substantial form is a sort of informing soul, which gives the thing its specific nature and all its properties and powers. Thus the substantial form of heavy bodies, is that which makes them descend; of light bodies that which makes them ascend. The substantial form of gold is that which gives it ductility, weight, colour, and its other qualities. Gravity, levity, fluidity, hardness, heat, cold, and all other known properties, were held to originate from the substantial form of the body; and generation, and corruption, and *occult qualities*, were ever at hand to account for every change which might occur. A change in the accidental form of any body is alteration only; a change in the substantial form is generation and corruption. It is corruption, with respect to the substantial form of which the

body is deprived; it is generation, with respect to the substantial form that succeeds,

Descartes was born at La Haye, in Touraine, A.D. 1596. In his "Discourse on Method," he informs us that it became with him an early determination to break through the trammels of school learning and to examine everything for himself, irrespective of the dogmas of all past philosophies.

The mind is the judging principle; it alone deals with the right and the wrong, the true and the false, therefore Descartes felt convinced that there must be a way of questioning it, and extracting from it great and important truths.

In order to train his mind to the habit of sagacious and dispassionate judging, he, when twenty years of age, entered the army, and served as a volunteer under Maurice of Orange, and afterwards under Tilly. After this he sought still further to enlarge his understanding by nine years devoted to travel and observation, applying himself to all important questions, moral, social, and political. These years, he informs us, had however passed away before he had come to any determination respecting the difficulties which form matter of dispute among the learned, or had commenced to seek the principles of any philosophy more certain than the vulgar. He accordingly saw it necessary to remove from all those places where interruption from any of his acquaintances was possible, and with that view he settled in Holland, where he endeavoured to adjust his thoughts on the great subject with which his spirit laboured, namely, the reconstruction of philosophy on a simpler and surer basis. He tells us that exactly eight years after this self-compelled exile, he sat down to commit his views to paper.

The style of Descartes possesses all that clearness and grace by which the best writers of his country are preeminently distinguished, so that almost any ordinary reader will derive pleasure from the perusal of his principal philosophical productions, the "Discourse on Method," the "Meditations," and the "Principles of Philosophy."

From observing the success of mathematical reasoning, Descartes was led to believe that all things, to the knowledge of which the mind was competent, might be reached by the same process of reasoning, provided only we make sure of each step as we proceed.

To get such sure foundations, he tells us, he determined to reject, as absolutely false, all opinions in regard to which he could suppose the least ground for doubt existed, in order to ascertain whether after that there remained aught in his belief that was wholly indubitable. Accordingly, seeing that our senses sometimes deceive us, he was willing, in the first instance, to suppose that there existed nothing, really such, as the senses present it to us. "Immediately upon this observation," says he, "I observed that whilst I wished to think that all was false, it was absolutely necessary that I, who thus thought, should be something, and as I observed that this truth, 'I think, therefore I am' (*cogito ergo sum*) was so certain, and of such evidence that no ground of doubt, however extravagant, could be alleged by the sceptics capable of shaking it, I concluded that I might without scruple accept it as the first principle of the philosophy of which I was in search. ("Method," Part II.)

"In the next place I attentively examined what I was; and as I observed that I could suppose that I had no body, and that there was no world nor any place in which I might be, I thence concluded that I was a substance, whose whole essence or nature consists only in thinking, and which, that it may exist, has need of no place, nor is dependent on any material thing, so that 'I,' that is to say, the mind, by which I am what I am, is wholly distinct from the body, and is even more easily known than the latter, and is such, that although the latter were not, it would still continue to be all that it is."

This mode of predicating the separate independent substance of the soul as a thinking principle was a bold first step; and modern philosophers will judge whether his

arguments are to be held as demonstrations, or merely as the authorised conclusions of reason in dealing with intuitive, constructive, circumstantial, or other evidence, and whether we have more than yields us only probabilities.

Descartes then proceeds: "After this, I inquired in general into what is essential to the truth and certainty of a proposition; for since I had discovered one which I knew to be true, I thought that I must likewise be able to discover the ground of this certitude; and as I observed that in the words, 'I think, therefore I am,' there is nothing at all which gives the assurance of their truth beyond this, that *I see very clearly that in order to think it is necessary to exist*, I concluded that I might take as a general rule the principle that *all the things which we very clearly and distinctly conceive are true, only observing, however, that there is some difficulty in rightly determining the objects which we distinctly conceive.*"

Next as to the mind witnessing to the being of God. We give Descartes' statement shortened:—

"In the next place, from reflecting on the circumstances that I doubted, and that consequently my being was not wholly perfect (for I clearly saw that it was a greater perfection to know than to doubt), I was led to inquire whence I had learned to think of something more perfect than myself; *and I clearly recognised that I must hold this notion from some nature which, in reality, was more perfect; and to receive it from nothing was a thing manifestly impossible;* and because the idea is not less absurd, that the more perfect should be an effect of and dependent on the less perfect, than that something should proceed from nothing, it was equally impossible that I could receive the above notion from myself; accordingly, it but remained that it had been placed in me by a nature which was in reality more perfect than mine, and which even possessed within itself all the perfections of which I could form an idea; that is to say, in a single word, which was God.

"In the next place I perceived that there was nothing at all

in the demonstration of geometers, which could assure me of the existence of their objects; thus, for example, supposing a triangle to be given to my mind, I distinctly perceived that its three angles were necessarily equal to two right angles, but I did not, on that account, perceive anything that could assure me *that any triangle existed*, while, on the contrary, recurring to the examination of the idea of a perfect Being, I found that the existence of the Being was comprised in the idea; in the same way that the equality of its three angles to two right angles is comprised in the idea of a triangle, and that consequently it is at least as certain that God, who is this perfect Being, is, or exists, as any demonstration of geometry can be."

Clearness and distinctness in our conceptions, whether of God or of the external world, are with Descartes the sufficient criterion of their real existence, and this because such clear conceptions are derived from a perfect Being. Whence he says it follows that our ideas or notions, which to the extent of their clearness and distinctness are real and proceed from God, must to that extent be true.

These are high and difficult questions. We shall find, however, that Descartes' conceptions, whether of mind or matter, are generally sagacious, and many of them wonderfully correct. We shall now glance over several of his conclusions as stated in his "Principles of Philosophy."

In order to seek truth it is necessary once in the course of our life to doubt, as far as possible, of all things.

We cannot doubt of our existence while we doubt; and this is the first knowledge we acquire when we philosophise in order. Accordingly, the knowledge, *I think, therefore I am*, is the first and most certain that occurs to one who philosophises orderly. The notion we have of our mind thus precedes that of any corporeal thing, and is more certain, seeing we still doubt whether there is any body in existence while we already perceive that we think.

The greater objective perfection there is in our idea of a

thing, as, *e.g.* in a picture, or in an ingenious machine, the greater also must be the perfection of its cause.

Because we discover in our minds the idea of God, or of an all-perfect Being, we have a right to inquire into the source whence we derive it, and we discover that the perfections it represents are so immense as to render it quite certain that we could only receive it from an all-perfect Being; that is, from a God really existing. For it is not only manifest that nothing cannot be the cause of anything whatever, and that the more perfect cannot arise out of the less perfect, so as to be thereby produced as by its efficient and total cause, but also, that it is impossible we can have the idea or representation of anything whatever, unless there be somewhere, either in us or out of us, an original, which comprises in reality all the perfections that are thus represented to us.

God is not the cause of our errors; consequently, all which we clearly perceive is true, and we are thus delivered from the doubt above proposed.

The chief perfection of man is his being able to act freely, or by will, and it is this which renders him worthy of praise or blame.

We shall be free from embarrassments in reconciling the freedom of our will with the Divine pre-ordination if we recollect that our mind is limited, while the power of God, by which He not only knew from all eternity what is, or can be, but also willed and pre-ordained it, is infinite.

We shall never err if we give our assent only to what we clearly and distinctly perceive; but it must be not only clear, but also distinct. From the example of pain it is shown that a perception may be clear without being distinct, but it cannot be distinct unless it is clear.

When we apprehend that it is impossible a thing can arise from nothing, this proposition, *ex nihilo nihil fit*, is not considered as something existing, or as the mode of a thing, but as an eternal truth, leaving its seal in the mind, and is called an axiom.

By substance we can conceive nothing else than a thing which exists in such a way as to stand in need of nothing beyond itself in order to its existence; and, in truth, there can be conceived but one substance which is absolutely independent, and that is God.

Of every substance there is one principal attribute: as thinking, of the mind; extension, of the body.

Universals, viz. genus, species, difference, property, and accident, arise merely from our making use of one and the same idea in thinking of all individual objects between which there subsists a certain likeness.

The perceptions of the senses do not teach us what is really in things, but what is beneficial or hurtful to the composite whole of mind and body.

All the properties we distinctly perceive to belong to matter are reducible to its capacity of being divided and moved according to its parts; and, accordingly, it is capable of all those affections which we perceive can arise from the motion of its parts.

Although the human soul is united to the whole body, it has, nevertheless, its principal seat in the brain, where also it not only understands and imagines, *but also perceives;* and this by the medium of the nerves, which are extended like threads from the brain to all the other members, with which they are so connected that we can hardly touch any of them without moving the extremities of some of the nerves spread over it; and this motion passes to the other extremities of these nerves, which are collected in the brain round the seat of the soul. But the movements which are thus excited in the brain by the nerves variously affect the soul, or mind, which is intimately conjoined with the brain, according to the diversity of the motions themselves, and the diverse affections of the mind, or thoughts, that immediately arise from these motions, are called perceptions of the senses, or, as we commonly speak, sensations.

The varieties of these sensations depend, firstly, on the

diversity of the nerves themselves, and, secondly, on the movements that are made in each nerve.

It can be proved that our mind is of such a nature that the motions of the body alone are sufficient to excite in it all sorts of thoughts, without it being necessary that these should in any way resemble the motions which give rise to them, and especially that these motions can excite in it these confused thoughts called sensations. For we see that words, whether uttered by the voice, or merely written, excite in our minds all kinds of thoughts and emotions. On the same paper, with the same pen and ink, by merely moving the point of the pen over the paper in a particular way, we can trace letters that will raise in the mind of the reader the thoughts of combats, tempests, or the furies, and the passions of indignation and sorrow; in place of which, if the pen be moved in another way, hardly different from the former, this slight change will cause thoughts widely different from these; such as those of repose, peace, pleasantness, love, and joy.

By our senses we know nothing of external objects beyond their figure, magnitude, and motion.

Sensible objects are composed of insensible particles.

These extracts will show how completely Descartes had freed himself from the trammels of the schools; and more than this, how much of the science and the thought of the nineteenth century were anticipated by this able man, who has deservedly received the title of the founder of modern philosophy.

CHAPTER XXXII.

DIFFICULTIES ARISE.

GEULINX—MALEBRANCHE—SPINOSA—LEIBNITZ.

IT is by means of free discussion and the efforts of different minds that human knowledge is advanced, and that we learn to separate the false from the true. We do not strike at once upon the lode which is to enrich the world, but at different times we gather up fragments which reward the seeker, and which convince him that the metal exists.

Descartes' distinct enunciation of the separate nature of mind and matter has probably called forth more philosophical reflection than any metaphysical doctrine which has been proposed since the days of Roscelinus. The first person who found difficulties to arise from the reception of this doctrine was Arnold Geulinx (born in Antwerp, 1625, and who died Professor of Philosophy, at Leyden, 1669). If the mind and the body, said Geulinx, possess entirely different natures, how can the one be associated with or act on the other? How can an impulse on the organs of sense affect the mind? And how can the mind produce voluntary movement of the body? It is impossible. It is, therefore, God alone who connects the one with the other. The operations which seem to connect the outer or physical part with the inner or spiritual part of our nature are only apparent. God is the real cause. When I form a volition, it is not my will which moves the body, it is the Being who presides throughout nature who is the real agent, and who, *on the occasion* of my will, moves my body. On the occasion, again, of an affection of my body, He also excites

the requisite idea or perception in my mind. The outward object is but the *occasion* or *occasional* cause of perception. This theory we will find has ever since in different shapes held possession of the minds of eminent men, both abroad and in our own country. If, says Schwegler, Descartes called the union of soul and body a *violent collocation,* Geulinx calls it, in so many words, *a miracle.* Sir W. Hamilton employs the same epithet with reference to the principles of Reid and Stewart, charging them with holding that all our perceptions of external objects imply the interposition of miraculous power.

Nicolas Malebranche, one of Descartes' most eminent disciples (born at Paris, 1638) perceived the difficulties which arose from Descartes' doctrine of the essential duality of mind and matter, but he escaped from them by holding that *we perceive all things in God.* A simple and sublime theory, and not without warrant, especially if we consider the views then prevalent regarding ideas. It was generally held that ideas, or mental images were, in perception, presented to the mind. Malebranche concurred with Descartes in holding that the mind, being spiritual, cannot be directly cognisant of matter. It cannot have *material things* presented to it in perception. These cannot be believed to be capable of producing ideas. There seemed, then, no alternative but to hold that these ideas are communicated by a competent spiritual agent, namely, by God. He is the creator and sustainer of all things; He is present in all His works; He is especially *the place of spirits.* In Him we live, and move, and have our being. Our spirits are in union with Him although we know it not, and it is by this union that we perceive *the ideas of all things which are in Him.* Deity does not, on this theory, give us the ideas as Geulinx taught; but the mind in union with Deity is free to direct itself to the ideas and perceptions which are thus within its reach. It is alleged that Malebranche would have discarded matter altogether had he not been debarred by his Church, which required a belief in the corporeal presence in the

Eucharist—a belief considered incompatible with the denial of matter.

Spinosa chronologically followed Descartes. In his Ethics he endeavours to prove, by the rigid exercise of thought, that there is and can be only one being, or substance. God is the sole existing substance, viewed as the infinite substance. He is the same as nature—*natura naturans*. But viewed objectively, with reference to the modes under which the Divine attributes appear to us in nature, He is *natura naturata*. The intellectual world, again, or the operation of thought in man and in other creatures, is also *natura naturata*, or God manifesting Himself according to the laws of thought. Thought, according to Spinosa, is not a faculty but an act, and it proceeds according to natural law. Our ideas and nature's laws are co-relatives. This is Platonic! The idea and objective reality are one, and God is ~~the~~ ~~*idea*~~ *immanens*, present in all thought and in all reality. The one infinite substance, according to Spinosa, has two infinite attributes—extension and thought. Extension has no bounds, and thought has no limit. Spinosa held with Descartes, that no clear idea can be false, for there can be no such idea without God, and all ideas in God are true. Falsity, therefore, arises from *inadequate ideas*—error is imperfect truth. The *existence* of God may be conceived; indeed, it is a necessary conception which no mind can escape from, but the *manner of His existence* can never be conceived.

Such are some of Spinosa's leading doctrines. He regarded them not as founded on theory, but as solid and unchallengeable truths, which are self-evident so soon as we deal closely with the elementary ideas found in the mind, and which therefore pertain to universal reason.

The whole of his system he founded on eight definitions, and seven axioms, which however we shall not here present to the reader; the due consideration of them might occupy a lifetime, and would at least take us away from the objects we have in view.

The idea of a one existence is undoubtedly the grandest idea which man can form, and many minds are, by long reflection, irresistibly drawn to this conclusion. The existence of an infinite, spiritual Being is an essential idea, and it is an idea sufficient to explain all phenomena; for even if we imagine matter to exist, the reflection is clear that matter without active power, is mere body possessing extension, and is therefore unthinkable as substance; and so soon as we conceive power as existing in the world, there rises up the conception of a spiritual existence, for power we necessarily conceive as an attribute of mind.

We part with Spinosa, merely remarking that he must ever be regarded as one of the best specimens of a man living amidst abstractions and resting calmly on the conclusions of his own mind; satisfied with what exists, however bitter it may be, because he believes it to be the result of an eternal necessity which must be right and good.

We may mention Leibnitz, also (born at Leipsic, 1646), but merely to convince the reader how powerfully the distinction, dogmatically urged by Descartes, between mind and matter influenced subsequent thought. It was this that prompted Leibnitz's well-known theory of monods and a pre-established harmony. He held that the mind and the body are absolutely independent of each other, but that by virtue of a harmony, established at the Creation between them and all monods, they act in apparent concert. The nature of their action he illustrated by the supposition of two clocks, one of which is made to point, while the other strikes, the hours. In like manner our sensations, he held, afford us a knowledge of the condition of the body, and our acts of volition accompany, but do not cause, the movements of the limbs.

CHAPTER XXXIII.

LOCKE.

HITHERTO we have been entirely occupied with foreign writers and thinkers. We are now to bring an Englishman on the platform, and one who is in every respect a representative man. The English mind is solid, sagacious, and practical, rather than imaginative, subtle, or metaphysical; and they who read Locke will find how strongly the national characteristics were rooted in the English philosopher.

Plato had held the human mind to be stored with mysterious abstract ideas, having reference to knowledge acquired in a previous state of existence. The Neo-platonists had laid great store on inspired knowledge. Descartes had strongly maintained the existence of ideas innate to the mind, and that the belief in the existence of God was one of the most certain and immanent of all our ideas. Spinosa held the existence of God provable by the laws of thought directed to the consideration of *substance* or *existence*. Locke, in contrast with all these, felt himself constrained to deny, absolutely and entirely, the existence of innate ideas. "Ideas," says he, "are no more born with us than the arts and sciences." "But," says he again, "I doubt not but to show that a man, by the right use of his natural ability may, without any innate principles, attain a knowledge of a God, and other things that concern him. God having endued man with those faculties of knowledge which he hath, was no more obliged by His goodness to plant those innate notions in his mind, than that, having given him reason, hands, and materials, He should build him

bridges or houses." And if this *idea of a God* is not innate, argues Locke, much less should we expect to find any other innate ideas in the mind. (B. I. ch. i. and iv.)

Locke accordingly conscientiously urged that "philosophy founded on such speculations was vain, because they transcended the reach of man's faculties." "I thought," says he modestly, "that the first step towards satisfying several inquiries the mind of man was very apt to run into, was to take a view of our own powers, and see to what things they were adapted. Till that was done, I suspected we began at the wrong end, and in vain sought for satisfaction in a quiet and sure possession of truths that most concerned us, whilst we let loose our thoughts into the vast ocean of being, as if all that boundless extent were the natural and undoubted possession of our understandings, wherein there was nothing exempt from its decisions, or that escaped its comprehension." (B. I. ch. i.) Locke accordingly set himself honestly to this task.

"First," says he, "I shall inquire into the origin of those ideas, notions, or whatever else you please to call them, which a man observes, and is conscious to himself he has in his mind, and the ways whereby the understanding comes to be furnished with them.

"Second. I shall endeavour to show what knowledge the understanding hath by those ideas, and the certainty, evidence, and extent of it.

"Thirdly. I shall make some inquiry into the nature and grounds of faith or opinion, whereby I mean that assent which we give to any proposition as true, of whose truth yet we have no certain knowledge; and here we shall have occasion to examine the reasons and degrees of assent."

This was a most important undertaking, and one made with the right spirit and in the right direction; and to Locke is due the great merit of having been the first who, by a sober, careful, and homely examination of the phenomena of consciousness, attempted to ascertain the nature, origin, and extent of human knowledge.

Locke begins his great work, the essay concerning "The Human Understanding," which he dedicated to the Earl of Pembroke (in May, 1689), by an elaborate attack on the doctrine of innate ideas. This he explains as the doctrine "that there are in the mind certain innate principles, primary notions, characters as it were, stamped upon the mind of man, which the soul receives at its very first being, and brings into the world with it." Locke endeavours to show that so far from this being the case, human knowledge is all derived, first, from the *ideas* (sensations) we receive through the senses; and, secondly, by the operation of reason or, as he calls it, reflection, such as thinking, doubting, reasoning, knowing, willing, and all the other actings of our own minds. "All our ideas," says he (B. II. ch. i.), "are of one or other of these. The understanding seems to me not to have the least glimmering of any ideas which it doth not receive from one of these two. External objects furnish the mind with the ideas of sensible qualities, which are all those different perceptions they produce in us; and the mind furnishes the understanding with ideas of its own operations."

Having thus satisfied himself that the first source of knowledge is derived through the senses, in the form of those *ideas* which we call sensations, he expresses himself thus regarding the second or inner sense, which he calls reflection: "The other fountain from which experience furnishes the understanding with ideas, is the perception of the operations of our own mind within us, *as it is employed about the ideas* (sensations) it has got."

These words, which we have marked in italics, might seem, if strictly interpreted, not only to exclude all possibility of ideas innate, or born with us, as Locke understood them, but also, as one might conclude, all possibility of ideas on subjects which have not affected us through the senses. This latter conclusion, however, would be unjustified, for, as we shall see, Locke held very strongly that, by the proper use of reason, we must surely be conducted to a belief in the

existence of a God. If it be so, then reason has to do with more than the objects of sense, and Locke's language was loose and unguarded; for, from whence arise our ideas of God or of the mind; and whence arise our emotions of love, hate, envy, love of approbation, sense of duty, sense of shame, etc.? None of these complex emotions, if properly regarded, enter the mind through the senses, or can be formed by any combination of visual or tactual sensation. Had Locke been only a little less bent on demolishing what he regarded as the false conceptions then prevalent regarding innate ideas, he would, undoubtedly, in spite of his desire to simplify our mental operations, have got a glimpse of the philosophy of later times, and have seen, that though the mind is not born with ideas, yet it is born the subject of laws which regulate and determine, not only the nature of its sensations and emotions, but also the nature of its deductions, inferences, and judgments, all of which are as dependent on the laws and constitution of the mind, as the qualities of an apple or of a cherry are dependent on the properties of the trees on which these fruits grow.

Locke did not apprehend the active, transmuting properties of the mind. Hence his comparison of the mind, before it receives the first impressions of sense, to a sheet of white paper. "Let us suppose," says he, "the mind to be as we say, white paper, void of all characters, without any ideas. How comes it to be furnished? Whence comes it by that vast store which the busy and boundless fancy of man has painted on it, with an almost endless variety? Whence has it all the materials of reason and knowledge? *To this I answer in one word, from experience.*"

On other occasions Locke compares the mind to a dark cabinet or room, into which enter "external *visible resemblances*, or ideas of things without. Would the pictures coming into such a dark room but stay there, and be so orderly as to be found upon occasion, it would very much resemble the understanding of man in reference to all objects of sight,

and the ideas of them." This was an unfortunate comparison, holding true scarcely on one point, and differing always more, the more we inquire into it.

Notwithstanding the many obligations we owe to Locke, there are several very prominent defects in his philosophy. There are errors of omission and errors of commission, and very important were the consequences which flowed from these. It is but a light charge to advance against one who has ventured upon a comparatively untrodden field of research, that he has failed to exhaust all its contents; but a much heavier charge has been brought against the English philosopher; and it must be regretted that the honest, acute, and eminently pious Locke, should, owing to the extremely sensualistic character of his views, be pretty generally regarded as the originator of a wide flood of false philosophy. Thus he is arraigned as having unwittingly led the way to almost every modern error — to the scepticism of Hume—to the sensationalism and sensualism of Condillac and Helvetius—to the atheism of Lamettrie—and to the scoffing, loose-toned morality of the French Encyclopedists. All these writers, it is alleged, claim Locke as their leader; and their conclusions, it is maintained, followed naturally in the wake which the strictly religious English philosopher had traced out for them.

This heavy censure Locke exposed himself to by the course he took in his unqualified attack on what he considered the errors and assumptions of previous philosophers; and it is to be much regretted, no doubt, that Locke, notwithstanding the acuteness and sagacity which pervade nearly every page of his great work, should, in the heat of his assault on innate ideas, have failed to discover the true nature of the doctrine, and that when properly examined and explained it brings to light psychological laws of the very highest importance. This, however, was a misfortune which an honest ardour drew him into, and few original inquirers have hitherto proved themselves sufficiently magnanimous to escape such errors and influences.

Locke evidently thought that philosophers had soared too high, and it would seem he had determined to show to how humble a level he could bring down what he considered a too pretentious structure. In carrying out this object, he applied himself too exclusively to the simpler operations of the mind in forming conceptions of external objects, and he allowed himself far too little time to consider the mind itself as the principle which forms those reflections and judgments, of which he so extensively and so ably treated. This, joined with the homely simplicity of his language, and the occasional grotesque familiarity of his illustrations, tended also in some measure to rob the subject of which he treated of its proper native dignity. But, far beyond any lowering influence of colloquial language, is his habit of making our sense perceptions appear as a simple transference into the mind of what exists in the outer world. By representing perception in this light, in opposition to the better views of his predecessor Descartes, Locke withdraws our attention from the part which the mind plays in the act of perception, and from considering the transformed character which all physical impressions undergo when brought into its presence. This being the case, we can see how easy it was for those who were so disposed, by sinking somewhat farther out of sight the already too much neglected mental factor, to debase Locke's philosophy into a system of pure and absolute materialism.

Locke's attack on innate ideas may indeed be defended in so far as it was an exposure of the false or inadequate conceptions regarding them which, since the days of Plato, had widely prevailed, and which even the clearer views of Descartes had failed sufficiently to correct. But though in this light the writings of Locke may have served a useful end, by setting men on a more careful inquiry into the subject, yet we cannot conceal what is now fully admitted, that the human mind contains depths which the common sense and sagacity of Locke failed to discover.

Locke's off-hand dismissal of innate ideas was not, however, his only failure. His treatment of the moral sense was even more unfortunate. Perceiving that neither among nations nor individuals was there found to be any one absolutely fixed rule of *right*, Locke was led virtually to deny to man the possession of a moral sense. According to his theory, man's best motives may be, nay are, resolvable into a principle of more or less refined selfishness. He seems to have failed to discover, and he certainly never teaches, that there is any connection between right and wrong as objective realities submitted to reason and the moral sense as discriminating principles; on the contrary, he bases our moral judgments entirely on external and conventional rules. He did not apparently see that by the term moral sense is not meant a sense which affords to all men one unvarying rule of conduct, but that the term means simply the possession of a law of mind which presses on creatures endowed with reason—the *felt obligation* to give effect to the convictions at which they may arrive by the free exercise of their faculties—in other words, a sense of duty. In treating of this subject, Locke, as if animated by nothing so much as the desire to simplify, is led to represent our motives to action, not as springing in any instance from a desire to accomplish an external or an inward good, but as being prompted by the simple desire to remove *uneasy sensations;* thus falsely making a mere accompaniment appear as the actuating cause of action.

To deny a moral sense because we cannot discover any fixed rule of morals among different nations, is almost as absurd as to deny the existence of a sense of hunger because we observe a diversity of tastes among different individuals or to deny a sense of beauty because different tribes select different types. It is to make expressions which are constantly in our mouths—such as, *a sense of duty*, *a sense of right and wrong, a sense of obligation*—empty forms of speech, possessing no meaning. It is true that there can be

but one perfect or absolute standard of morals, and the highest we can conceive is the Christian standard: Render not evil for evil; love your enemies; do good to those who despitefully use you. But while this is recognised as the aim of Christendom, we do not find that any Christian nation has yet ventured to practise it to the letter; on the contrary, human governments render to every criminal a punishment proportioned to his offence; in doing this they act in accordance with the laws of Providence, which make misery and distrust the accompaniments of guilt. Practically then, it would seem that human codes must vary with varying circumstances. Under their judges the Jewish people, in order to the repression of rapacity on the one hand and of unmeasured retaliation on the other, were permitted to claim an eye for an eye and a tooth for a tooth; but a time arrived when a higher standard could be proclaimed, and quickly the world recognised the obligation of that higher rule, however imperfectly they might see their way to bring it into practice. There exists then, it would seem, among nations a much wider difference in their practice than in their theory of morals. This fact Locke should have seen.

These were the chief points in Locke's celebrated work which require to be pointed out for condemnation. If taken literally, they are sufficient to justify the charge of his having led the way to a materialistic philosophy. To be properly estimated, however, Locke's opinions must be viewed as a reaction from that loose, ambiguous, and often exaggerated use of doctrine which preceded his time; and we must keep in mind that though it is not difficult for us in the present day to see how far, in seeking to clear philosophy of supposed errors, Locke overshot the mark, yet it is but an act of justice to so great and good a man to recognise at once his manly honesty and his large success. They who carefully read Locke's writings, and judge for themselves, will not fail to discover how much information and profit may be derived from them, even in our enlightened

times; and how much there is in them of sound, fresh, and ingenious thought. His objectionable positions are now no longer dangerous; and they may even be regarded by us with interest, as having given an impulse which has ended in the clearing up of a subject which, but for Locke's challenge, might have much longer cumbered the field of philosophy with ambiguities and uncertainties.

CHAPTER XXXIV.

BERKELEY.

THE character of Bishop Berkeley is perhaps better known than that of most metaphysical writers. The singularity of his opinions, when once stated, is calculated to fix the attention of the unlearned, and to give notability to the author's name. From this cause we find many talking of Berkeley, and of his views, who have no expectation of ever reading a page of his writings. This species of renown is increased by the knowledge that he who did not believe in the existence of an external world was yet one of the most elegant and attractive of writers, and one of the most enthusiastic and benevolent of men.

We remember the day when Berkeley was to us a mere imagination and a myth; we have now for many years enjoyed him as a companion and a friend.

The epigrammatic encomium pronounced on him by Sir James Mackintosh, in his dissertation on ethics, is too well known for us to do more than select from it a single sentence. "Ancient learning," says Mackintosh, "exact science, polished society, modern literature, and the fine arts, contributed to adorn and enrich the mind of this accomplished man." Even the discerning, fastidious, and turbulent Atterbury said, after an interview with him, "so much understanding, so much knowledge, so much innocence, and such humility, I did not think had been the portion of any but angels till I saw this gentleman."

Berkeley was indeed a rare instance of a man of genius who, though engrossed throughout life with the most abstract

studies, yet succeeded in preserving his natural grace and attractiveness; and who, though favoured and flattered by the noblest and most powerful of the land, yet retained untainted all his native Irish simplicity, enthusiasm, and goodness.

Berkeley's character will be found much more truly reflected in his writings than in any of his stray letters, diaries, or other private papers which have been preserved.

These, the usual resources of biographers, are unfortunately both scanty and unsatisfactory. His letters especially, mostly bear the impress of having been written by one who tore himself unwillingly from books and philosophical elaborations, merely to implore his friends to arrange, and keep in some sort of order, his outward affairs. They are much about money, about leases of demesne lands, repairs of houses, and other troublesome externals, very discomposing evidently, and wearisome to an idealist.

We cannot but wish that Berkeley's philosophical writings were more widely read in our day than they are. We are certain that not merely as models in style, but as the means of introducing the mind to much curious philosophical discussion, and to the exercise of abstract thinking, they would be found in a high degree both interesting and instructive. They whose minds have not been previously exercised in this way, would thus, more pleasantly than by any other means, become acquainted with some of the subjects with which the philosophical world has, for many years, occupied its attention. And here we may, once for all, remark with reference to the metaphysical writers of our country, as with reference to English literature generally, that our best authors have aimed after sympathy with their readers, and have endeavoured to commend their views by setting them forward in a clear and simple guise, rather than to invest them with a fictitious value through a studied obscurity of language. While we all know that some of the finest literature of ancient and modern times has been devoted to the treatment of moral and philosophical subjects, we find

also, as if to show the various working of the human mind, that some of the most influential and ingenious writers of other lands have found it impossible to give delivery to their ideas except in language which seems to us both inflated and difficult to understand.

Some of this class, notwithstanding their undoubted genius, we can never escape thinking were afraid of putting the matter in a position for their readers to estimate the amount and value of what they had to present, and the precise foundation on which it rested.

Berkeley was not one of these; his foremost desire is to produce conviction in the mind and heart of his readers, though in his urgency, we confess, we find him frequently not a little sophistical.

George Berkeley was born on 12th March, 1684, at Killerin, in the county of Kilkenny. He became an author, and wrote a Latin treatise on arithmetic, before he was twenty years of age.

In 1709, when only twenty-five years of age, he wrote his famous "Essay towards a New Theory of Vision." This treatise was so sound, and so well thought out, that his positions at once commanded the assent of most intelligent readers: this must be the case at least with regard to its leading doctrines. In an optical point of view his theory may be briefly thus explained. Vision, and the knowledge we possess of the size, distance, form, and posture of objects, are not, as had been explained by some philosophers, intuitional perceptions of these particulars, nor is our knowledge of them, as was to a large extent believed by optical writers before Berkeley's time, dependent on mathematical and physical laws. Our usual perceptions, Berkeley shows, are, strictly speaking, acts of judgment pronounced on the various visual presentations which that sense lays before us; and our means of forming our judgments are, as he distinctly proves, originally acquired and verified by locomotion and the sense of touch.

We think we are not wrong in saying that the larger portion of these opinions of Berkeley are naturally held by

most unsophisticated persons who think on the subject. They know that we judge of distance by a silent synthesis of various circumstances; as for instance, the apparent size, the distinctness or obscurity of the objects, the number of objects which intervene between them and the observer, and all the other indications of every sort which present themselves; and, lastly, by the time and the walking power expended in reaching the object. It was the attempt of optical writers to appear scientific which misled general common sense on this subject. They insisted upon the lines of perspective, the direction of the rays of light, the angles at which these fall upon the retina, the consequent lines of visual direction, the converging angles of the ocular axes, and many other geometric particulars, which in themselves have no *direct* bearing on the subject of perceptive knowledge.

Still, though common sense was nearer the truth than science, it was never supposed, nor indeed is it yet generally known, that vision by itself gives us no knowledge of the distance, size, direction, and posture of objects, and that, without powers of locomotion and touch, we could never acquire a knowledge of these.

Berkeley, besides the scientific object he had in view, explained his theory of vision in language which at the same time squared with his ideal views. Thus he represented the presentations of the visual sense as signs or ideas, whose meaning is only known and interpreted by other signs or ideas, which are called tactual, and which are given us by another sense. And Bishop Berkeley's learned editor and commentator, Professor Fraser, very ingeniously, as we shall shortly see, also represents it in this light, and enlarges on the mysterious connection of ideas which the Author of our being has established between the signs of two senses so entirely dissimilar as those of touch and vision.

We confess that, as realists, we see nothing at all remarkably wonderful in the fact that the decreased angular breadth of a house, the visual sign, should by experience lead

us to the conclusion that we shall have to walk a considerable distance before we can *touch* the building; or that when we see the well-known appearance of oranges in a dish, we should be able to calculate with certainty that by a movement of the arm we may have one of them in our hand. If there were no real oranges, but only the ideas of them, it would indeed be marvellous that the idea of, say, six yellow circles should so invariably be followed by signs or ideas of one round body in the hand of the beholder, and five still lying in the dish; for between the particular colour, as an idea, and the particular touch, also as an idea, there is, as the editor remarks, no discernible resemblance or connection.

Berkeley's "Principles of Human Knowledge" appeared in the year which followed the publication of his "New Theory of Vision," and in it, with great ingenuity, he endeavours to disprove the existence not only of matter as an entity, but of the world as an extended, external existence.

In February, 1713, he came to London, and published "Three Dialogues, between Hylas and Philonous, in Opposition to Sceptics and Atheists." In these the same immaterial theory is maintained. The subtlety of his arguments, the purity and grace of his language, and the easy play of imagination which pervaded these dialogues, at once gained for him the admiration of the literary circles of the metropolis, and his company was sought by Steele, Addison, Swift, Pope, and the other leading celebrities of the day. He shortly thereafter accepted the appointment of chaplain to the Earl of Peterborough, and by a year's travel over Europe, in his suite, he doubtless greatly enlarged his knowledge and his sympathies; he thereafter made a second and more extended tour, as tutor to the son of Dr. St. George Ashe, Bishop of Clogher. On his way home he wrote a treatise, "De Motu," and shortly thereafter, in 1721, he published an "Essay towards Preventing the Ruin of Great Britain," which was called forth by the disastrous South Sea Scheme. The year following he had the fortune, whether good or bad we do

not say, for it involved him in various anxieties and troubles, of finding himself left heir to one half the means and estate of Mrs. Esther Vanhomrigh, Swift's famous Vanessa. In 1721 Berkeley was by his patron, the Duke of Grafton, promoted to the deanery of Derry, with £1000 per annum.

Next came the most onerous and practical project of his life; to wit, a scheme to instruct the uneducated youth of America, and the uncivilized natives, in Christianity, by means of a college to be planted and endowed at the Bermudas; of this college he was to be president. For this philanthropic scheme he succeeded in gaining the temporary approval of George I. and his minister, Sir Robert Walpole; and through this influence he obtained a charter. The important matter of endowment had even so far made way in Parliament that Berkeley embarked, and settled, not in the Bermudas, but in Newport, Rhode Island, carrying with him his newly married wife, an artist named Sinibert, and three gentlemen of fortune. Here he resided four years, waiting anxiously the fulfilment of the promised endowment. The whole scheme, however, resting on the unwilling shoulders of Sir Robert Walpole, broke down, and Berkeley returned home, after having spent seven years of his life in anxieties, toils, and disappointments, and having expended a considerable portion of his private fortune in the support of the undertaking.

On the year of his return (1732) he published "Alcephron, or the Minute Philosopher. In Seven Dialogues, Containing an Apology for the Christian Religion against those who are called Freethinkers." In this he takes a wide excursion, dealing with the social, moral, and intellectual evils which accompany irreligion, and he shows, by the wonderful language of our senses, that we possess evidence of the presence of a wise and good being. In 1734 Berkeley was promoted to the Bishopric of Cloyne, in the south of Ireland; and here, in the faithful exercise of his ecclesiastical duties, he resided till 1752. After this he wrote the "Analyst," with a view to show that mysteries in faith are not to be unjustly objected to religion,

seeing that even in mathematics difficulties and doubtful doctrines emerge.

After this he wrote various useful papers on the social and political questions of the day; these we need not here ennumerate.

In 1744, in the decline of his life and vigour, he published his learned treatise entitled, "Siris: A Chain of Philosophical Reflections and Inquiries Concerning the Virtues of Tar Water."

In July, 1752, he removed, in an indifferent state of health, with his wife and children to Oxford, hoping there to spend the remainder of his days in that learned retirement so congenial to his tastes. Conscientiously sensitive on the subject of non-residence, he first however endeavoured to exchange his bishopric for a canonry, or other headship in Oxford. Failing in this, he wrote to the Secretary of State for permission to resign his bishopric, worth at that time about £1400 per annum.

It is said that his Majesty George II., hearing of what was considered an extraordinary request, declared in the most determined manner that his old friend should die a bishop in spite of himself.

Bishop Berkeley was not destined long to enjoy the repose he longed for. On Sunday evening, 14th January, 1753, just in the sixth month after his settling in Oxford, as he was sitting in the midst of his family, listening to a sermon of Dr. Sherlock which his wife was reading to him, he was seized with palsy in the heart, and instantly expired. Thus ended in peace the life of this laborious and eminently good man.

It is not very easy by a hurried glance to satisfy one's self of the exact nature of Berkeley's opinions. Though a master of language he is occasionally fond of casting his thoughts into a paradoxical form. Thus he at one time places his opinions as in opposition to those of the learned and metaphysical, and represents them as corresponding with those of the simple and ignorant. By and by, however, he states his

theory formally, and clearly enough denies the existence of matter; ere long he again seems to return to his original position, and, affirming the existence of the external world, employs the usual language of mankind in reference to it, and its belongings, and speaks of the size, distance, hardness, colour, smell, etc., of external objects—all this is puzzling enough, and it has led many of his readers, and some even of his commentators, to form false judgments regarding the nature of his views.

No doubt it is quite simple by quoting his own words to embody his theory in one short sentence, and to say *his world was in the mind.* This, however, does not sufficiently define his meaning; for most men may, by a little exercise of metaphysical ingenuity, be brought to admit that there is a measure of truth in the assertion that the world we feel, and see, and hear, and taste, and smell is in the mind, inasmuch as the sensations of touch, colour, sound, taste, and smell are only mental affections, and that, consequently, we know not the outward world itself, but only the inward mental affections which it produces within us. This was indeed the fundamental idea on which Berkeley founded. But over and above this view of the matter, while we keep in mind that Berkeley entirely denied the existence of the external world, it is necessary that we understand the way in which he accounted for the orderly impressions and beliefs in an external world which enter our minds and take possession of us.

Let us, then, hear what this ingenious author has to say on the subject; and let him state his views in those clear and telling sentences which he so well knew how to construct. We shall afterwards endeavour to summarize part of Professor Fraser's systematic recast of Berkeley's philosophy, offering as we best may our occasional remarks in opposition to the ideal theory. For brevity's sake we shall take the liberty of retrenching, so far as this can be done without injury to the author's meaning.

(" Principles of Human Nature," sec. 3.) " That neither our

thoughts, nor passions, nor ideas, exist without the mind is what everybody will allow; and to me it seems no less evident that the various sensations or ideas imprinted on the sense, however blended, that is, whatever object they compose, cannot exist otherwise than in a mind perceiving them. The table I write on, I say exists, that is, I see and feel it; and if I were out of my study I might say it existed, meaning thereby, that if I were in my study I might perceive it, or that some other spirit actually does perceive it. There was an odour, that is, it was smelled; there was a sound, that is to say, it was heard; a colour or figure, and it was perceived by sight or touch. This is all that I can understand by these and the like expressions. For as to what is said of the absolute existence of unthinking things, without any relation to their being perceived, that seems utterly unintelligible. Their *esse* is *percipi;* nor is it possible they should have any existence out of the minds, or thinking things, which perceive them."

(4.) "It is indeed an opinion strangely prevailing amongst men, that houses, mountains, rivers, and in a word all sensible objects, have an existence, natural or real, distinct from their being perceived by the understanding; yet whoever shall find in his heart to call this in question may, if I mistake not, perceive it to involve a manifest contradiction. For what are the forementioned objects but the things we perceive by sense, and *what do we perceive besides our own* ideas or sensations; and is it not plainly repugnant that any of *these* or any combination of them should exist unperceived?"

(9.) "Some there are who make a distinction betwixt *primary* and *secondary* qualities; and the ideas we have of colours, sounds, tastes, and so forth, they acknowledge not to be the resemblances of anything existing without the mind or unperceived; but they will have our ideas of the primary qualities, extension, figure, solidity, or impenetrability, to be patterns or images of things which exist without the mind, in an unthinking substance which they call matter. But it is evident from what we have already shown that extension, etc.,

are only *ideas existing in the mind.* Hence it is plain that the very notion of what is called *matter*, or *corporal* substance, involves a contradiction in it."

Observe how craftily Berkeley states his case : he dwells on the secondary qualities of bodies, their colours, sounds, tastes, and smells, which we all admit to be sensations in the mind, having no external equivalents, and he dismisses the real substantial properties, affirming that he had already proved them to be also in the mind.

We have only to ask ourselves, Does the admission, that the idea of an extended object is in the mind, involve the conclusion that no real extended object exists external to the mind? This is perhaps the most audacious assumption that was ever attempted, seeing that the reverse of it is the universal conclusion of the human race, which holds that expressly because the mind is conscious of extended objects, they must believe that such objects exist. Berkeley's position is substantially this, that because we have the feeling or sensation of an apple in our hand, therefore we must conclude there is no real apple existing. To rebut this conclusion, I have only to take up the directly opposite position and assert, *I am conscious only of external physical objects; as regards the mind as an invisible, unextended, intangible principle, I know literally nothing; at the best, I only infer its existence, but have no evidence of its essential nature.* To this position what has Berkeley got to answer?

Or suppose we assert the ordinary belief, that we are conscious of possessing a thinking, judging, and observing power, and are conscious of a wide-extending, physical world, and that we possess a body supplied with organs suited to convey external impressions to the brain, the seat of sensibility and thought, what objection can Berkeley offer to such a position on the score of consciousness on which he professes to take his stand? The truth is, Berkeley's whole theory is based, not on consciousness, as he asserts, but on a series of assumptions framed expressly for the purpose of supporting his

ideal views; and these assumptions, far from being probable, will be found, if we examine them, entirely improbable, irrational, and contradictory. Thus, first, he *assumes*—what most men *endeavour to prove*, but which they find themselves compelled to confess rests not on proof but on inference—that the mind is a spiritual principle distinct from the physical body; but anon he throws discredit on this, by assuming that the rational principle possesses no knowledge of things external, though, somehow or other, it is constantly occupied with the consideration of physical objects, which it judges to be external to itself. This, we say, is to represent the mind in a very irrational posture. Then, again, he denies the spacial existence of those physical bodies of which we are all directly or indirectly conscious. When the matter is put in this way, Berkeley has very little to answer. The belief that external objects exist, and that they have properties suited by the Being who formed them to act on the mind, we not only judge to be much more rational than the ideal theory, but we judge it to have a foundation much stronger than that of the inference on which he chooses to found his improbable theory. There has always, no doubt, existed a difficulty in conceiving the possibility of matter acting on mind, and mind on matter. This difficulty, however, is evidently one of our own creating; for we know nothing of the inner or essential nature either of mind or of matter; and, as we shall show in a future chapter, our difficulty mainly arises from our forming an unwarrantable conception of the nature and operation of that unknown entity which we call matter. It is by availing himself of the supposed difficulties connected with this entity that Berkeley succeeds in giving some show of strength to his position.

Thus he argues as follows, sec. 19:—" The existence of external bodies affords no explanation of the manner in which our ideas are produced. Though we give the materialists their external bodies, they, by their own confession, are never the nearer knowing how our ideas are

produced, since they own themselves unable to comprehend in what manner *body can act upon spirit*, and how it is possible it should imprint any idea in the mind, since it is evident the production of ideas or sensations in our minds can be no reason why we should suppose matter or corporeal substance, since that is acknowledged to remain equally inexplicable with or without this supposition. If, therefore, it were possible for bodies to exist without the mind, yet to hold they do so must needs be a very precarious opinion, since it is to suppose, without any reason at all, that God has created innumerable things that are *entirely useless, and serve no human purpose.*"

This argument may perhaps be employed with effect against the entity matter, as it is generally believed in, but Berkeley employs it as an argument against all external corporeal existence, which it certainly is not.

(23.) "But you say, surely there is nothing easier than to imagine trees for instance in a park, or books existing in a closet, and nobody by to perceive them, but *do you not yourself perceive or think of them all the while?* This therefore only shows you have the power of imagining or forming ideas in your mind; it doth not show that you can conceive it possible the objects of your thought may exist without the mind; to make this out, *it is necessary that you can conceive them existing unconceived, or unthought of, which is a manifest repugnancy.*"

This is quibbling. To conceive without conceiving, to think without thinking, is indeed impossible; but we experience no difficulty in thinking or conceiving that trees exist irrespective of us,—this is indeed the universal belief; neither has Berkeley any argument against trees growing while we are sleeping,—we all, like the laird of Dumbiedikes, believe that they do so.

The perplexed reader may probably here remark, if we seek a proof of external things existing, surely we may have it irrespective of any desire on our part to *think* of them;

thus in the dark we may unexpectedly knock our head against a post, or we may fall down a coal-pit. This, far from resulting from ideas, results from their absence; and, far from exciting ideas, it puts a sudden stop to all future sensation of any kind; and he may reasonably ask, Why should the idea of our falling down a pit be the necessary end of all our ideas? or why should swallowing poison without any idea of its existence produce the same fatal termination of all our mental activities?

Berkeley explains this in his own way. He, like other men, believes in what he calls the *laws of nature;* but these are with him, not the laws of external nature, neither are they, on his principle, the laws of mind; our sense perceptions he holds to be given us directly by the "supreme Mind on whom we depend."

On this theory of physics it is evident there exists no connection between one event and another, such as we have in physical causation; neither is there any real connection between human will and what are called events. Where there is no external world, man, of course, ceases to be an operative agent in the world. But let us hear the ingenious author.

(30.) "The ideas of sense are more strong, lively, and distinct than those of the imagination; they have likewise a steadiness and coherence, and are not excited at random as those which are the effects of human wills often are, but in a regular train or series; the admirable connection thereof sufficiently testifies the wisdom and benevolence of its Author, *now the set rules or established methods, wherein the mind we depend on excites in us the ideas of sense, are called the laws of nature,* and these we learn by experience, which teaches us that such and such ideas are attended by such and such other ideas in the ordinary course of things."

A knowledge of this order of succession, not in external events but in our ideas, Berkeley shows, in accordance with his ideal theory, is necessary for the conduct of our worldly affairs.

(31.) "This knowledge gives us a sort of foresight, which

enables us to regulate our actions for the benefit of life, and without this we should be eternally at a loss: we should not know how to act anything that might procure us the least pleasure, or remove the least pain of sense. That food nourishes, sleep refreshes, and fire warms us; that to sow in the seed-time is the way to reap in the harvest; and in general, that to obtain such or such ends, such or such means are conducive; all this we know, not by discovering any necessary connection between our ideas, but only by the observation of the settled laws of nature (*i.e.* of our sense ideas), without which we should be all uncertainty and confusion, and a grown man no more know how to manage himself in the affairs of life than an infant just born."

As Berkeley held all the sensations of what we call external objects to be confined to the mind, and to have no external counterparts, it follows, as we have said, that our ordinary notions of physical cause and effect are false, and that there is no dependence or connection between one event and another; that there is no such thing as an instrumental or physical cause of any event. In considering such a theory this difficulty will naturally present itself: If I witness an event, such as the spectacle of a friend falling down a coal-pit and being dashed to pieces, I may naturally inquire in what way the ideal theory deals with such a matter? how is it that such a startling and painful succession of ideas should be forced upon my mind? and why should all future intercourse between my mind and the mind of my friend be so suddenly brought to an end? I had no idea of the coal-pit before my mind's eye, neither had he; how are we to account for the history of so strange and unaccountable and calamitous a sequence of ideas? Berkeley does not work this very fully out, but had he entered upon it, he would doubtless have explained the chain of ideas as being ordered and arranged by the Author of our being, and thus, as standing in the place of what the realists call the laws of nature; and though the idea of the coal-pit was not

previously in my friend's mind or in mine, they were made to enter the mind, and to succeed one another, in accordance with the appointment of the Being who governs all things.

Another point involved in Berkeley's theory is this: where all are ideas and not realities, and there is no efficiency in any of the things which seem to flit across our consciousness, to what purpose exist those various ideas of this wonderful world—a world apparently stored with an infinite variety of animal, vegetable, and mineral productions? what object is served by what we call our bodies, so curiously and wonderfully framed? This question occurs to Berkeley. He states the objections and difficulties very fairly, and he manfully and very ingeniously, though not very successfully, endeavours to help us over them.

(60.) "It will be demanded, to what purpose serves that curious organization of plants and the admirable mechanism in the parts of animals? Might not vegetables grow and shoot forth leaves and blossoms, and animals perform all their motions as well without as with all that variety of internal parts so elegantly contrived and put together, *which, being ideas, have nothing powerful or operative in them, nor have any necessary connection with the effects ascribed to them?* If it be a spirit that immediately produces every effect by a fiat or act of his will, we must think all that is fine and artificial in the works, whether of man or of nature, to be made in vain. By this doctrine, though an artist hath made the spring and wheels, and every movement of a watch, and adjusted them in such a manner as he knew would produce the motions he designed, yet he must think this done all to no purpose, and that it is an intelligence which directs the idea and points to the hour of the day. If so, why may not the intelligence do it without his being at the pains of making the movements and putting them together? Why does not an empty case serve as well as another? and how comes it to pass that whenever there is any fault in the going of a watch there is some corresponding disorder to be found in the movements (the

internal parts), which, being mended by a skilful hand, all is right again? The same may be said of all the clockwork of nature, great part whereof is so wonderfully fine as scarce to be discerned by the best microscope."

Berkeley having thus anticipated the objections which might be urged against his theory from the observed mechanism of nature, proceeds thus to answer them. Some of his answers are mere assumptions framed in favour of his own views. His second answer is, however, suggestive of much reflection.

(61.) "Though there are some difficulties which I could not solve by the foregoing principles, yet neither are the received principles free from the like difficulties; for it may still be demanded, to what end God should take those roundabout methods of effecting things by instruments and machines which no one can deny might have been effectual by the *mere command of His will* without all that apparatus?"

Prosecuting this inquiry, Berkeley proceeds very ingeniously to show that, irrespective of any observed connection of cause and effect, the orderly arrangement and sequence of ideas (vulgarly events) is useful and necessary for our guidance.

(63.) "To set this matter," says he, "in a yet clearer light, I shall observe that what has been objected (sec. 60) amounts in reality to no more than this: ideas are not *any how and at random produced;* there being a certain order and connection between them, like to that of cause and effect. But since one idea cannot be the cause of another, to what purpose is that connection? and since those instruments, being barely inefficacious perceptions in the mind, and not subservient to the production of natural objects, it is demanded why they are made, or in other words, what reason can be assigned why God should make us, upon a close inspection into His works, behold so great variety of ideas so artfully laid together, and so much according to rule; it not being credible that he would be at the expense, if one may so speak, of all that art and regularity to no purpose?"

(65.) "To all which my answer is, *first*, that the connection of ideas does not imply the relation of *cause and effect*, but only of a mark or *sign* of the thing *signified*. The fire which I see is not the cause of the pain I suffer upon my approaching it, but *the mark that forewarns me of the pain*. In like manner the noise that I hear is not the effect of this or that motion or collision of the ambient bodies, but the *sign thereof*. *Secondly*, the reason why ideas are formed into machines—that is, artificial and regular combinations—is the same with that of combining letters into words. That a few original ideas may be made to signify *a great number of effects and actions* it is necessary they be variously combined together; and to the end their use be permanent and universal, these combinations must be made *by rule* and with *wise contrivance*. By this means abundance of information is conveyed unto us concerning what we are to expect from such and such actions, and what methods are proper to be taken for the exciting such and such ideas (*i.e.* perceptions), which in effect is all that I conceive to be distinctly meant when it is said that, by discerning the figure and texture and mechanism of the inward parts of bodies, whether natural or artificial, we may attain to know the several uses and properties depending thereon, or the nature of the thing."

Having advanced thus far, the next and most natural inquiry is, How are our sensations, or sense ideas, produced? Let us hear what Berkeley says on this important and mysterious point.

(90.) "Sensations are real things, or do really exist: this we do not deny, but we deny they can subsist without the minds which perceive them, or that they are resemblances of any architypes existing without the mind, since the very being of a sensation, or idea, consists in being perceived, and an idea can be like nothing but an idea."

(Query, may not the idea of a triangle be like a triangle, or the idea of squares or circles, and other figures, be like the external realities? Berkeley evades questions such as this.) But to proceed:—

"Again, the *things perceived by some may be termed external*, with regard to their origin in that they are not generated from within by the mind itself, but *imprinted by a spirit distinct from that which perceives them*. Sensible objects may likewise be said to be without the mind in another sense, namely, *when they exist in some other mind*. Thus, when I shut my eyes the things *I saw may still exist*, but it must (in that case) be in another mind."

This then is the only externality Berkeley admits, namely, that our sensations, or sense perceptions, are impressed, or caused by a spirit, and that when these are shut out from us, or from other conscious beings, they exist, or at least may exist, in the mind of Deity.

Such is Berkeley's ideal theory of the world. We hope the quotations given may afford a tolerably distinct representation of his meaning. We are glad, however, to have an opportunity of considering Berkeley assisted by the instructive explanations given by one in our own day, who is thoroughly competent to do justice to the subject. We refer to the notes and comments contained in the edition of Berkeley's works, lately edited by Professor Fraser, and especially to the valuable chapter explanatory of Berkeley's philosophy, contributed by the editor; and here, while we shall, as far as possible, avail ourselves of the commentator's own language, we shall, for brevity's sake, however unwillingly, use the privilege of abridging, and it may be occasionally transposing, without acknowledgment. All we have to say in preface is, that our respect for the writer shall not mitigate the freedom of our criticism.

"Berkeley," says Professor Fraser, "found Descartes, Malebranche, Locke, and other philosophers of the century in which he was born, trying, but with indifferent success, to verify the existence of matter, and he found even Locke suggesting that this same unperceived matter may be the cause of consciousness. Hobbes, indeed, dogmatically asserted more than this, assuming in his explanation of intelligent

man, that the body accounted for the mind, and that matter was the deepest thing in the universe. Spinosa, too, unfolded the Divine system according to a geometrical, which seemed to be a materialistic imagination of it; and, although the hypothesis, which resolves the material world into unextended monads, might place Leibnitz in a different category, it was an assumption almost as open to objection as that of the materialists, that a plurality of inconceivable forces is the constitutive essence of extended things. The material world was, in short, in many ways disturbing the balance of true belief in the beginning of the 18th century, and had always been doing so more or less. A powerful hand was required to put matters back into the proper place. Ascertain first, says Berkeley, what physical causality and physical substantiality can reasonably mean. Answer this first question, and you will find, he promises, that there will be no need to press the old demand for evidence of the existence of such a thing as physical substance, and that there will be no room for the old assumption about *the powers of bodies;* such existences, substantiality, and causality, as the actual world of the senses can be shown to be capable of having, that Berkeley assumes beyond all possibility of scepticism the unperceiving world has." He succeeds in doing this by assuming our sensations to constitute the world, and we cannot, of course, for one moment doubt of their existence, though we can of their power and substantiality. "As for causality," continues the Professor, "it turns out to be not efficient, but a divinely effected constancy of sensible order."

But to what extent are sensible objects real and external?

"A sensible thing," says the commentator, "involves more than the actual existence of what Berkeley calls sensations. The sensations are dependent on me, for they cannot exist as I now have them without me to be sentient of them: they are independent of me, for I am permanent while they are transitory, and their changes are independent of my will.

But this is not all, and actual sensations are often signs of sensations that are past, and also signs of future sensations, expected but not yet actual."

We may be allowed, perhaps, to illustrate the writer's meaning thus: when the geologist experiences visual sensations of large petrified lizards and mammoths, these sensations, which have been evoked within him, are signs of saurian and mammoth sensations, which have existed in Divine and angelic pre-Adamic minds in ages which have long since passed away. And when we experience visual sensations, as the sun declines, of our dwelling-house, we have assurance by these that, after certain acts of will, and certain tactual and locomotive sensations, all the other sensations vulgarly called,—sitting in an easy chair, with the sensation of a wife opposite, and the square idea we call a table, and the smaller ideas we call children, within easy tactual distance,—shall follow. And how have we this assurance? Because, as Berkeley says, the Author of all things has connected or associated the acts of our will, and our passive sensations, according to a regular order or sequence, to which we may trust. One actual sensation or group of sensations is thus the invariable mark of other sensations, not at the time actual (or felt). This relation of signs, Berkeley would say, is the only imaginable meaning of substantiality, or causality, when applied to the phenomena of sense.

"For us," says the learned editor, "the only practical and possible substantiality is permanence of co-existence or aggregation among sensations, and the only conceivable, and practical, and for us possible, causality among phenomena, is permanence or invariableness among their sensations.

"The material world is thus a system of interpretable signs, dependent for its actual existence in sense upon the sentient mind of the interpreter, but significant of guaranteed pains and pleasures and the guaranteed means of avoiding and attaining them; significant, too, of other minds and their thoughts, feelings, and volitions, and significant above

all of supreme mind, through whose activity the signs are substantial, and whose architypal ideas are the source of those invariable relations of them which make them thus practically significant.

"The material world, its substance or permanence, its powers and its space, thus resolve themselves into a flux of beautifully significant sensations, sense ideas, or sense phenomena, which are sustained in existence by a Divine reason and will. It is thus that the Berkeleyan reconciles Plato with Protagoras."

"When it is asked how the furniture of a room contrives to exist in the absence of a percipient, or how the substantiality or solidity of any object which we see can exist when we do not touch it, I reply, when I see an orange on a table without touching it, or applying any of my senses, except seeing, to it, most of the sense phenomena of which it consists are not actual, *as far as my sense consciousness of them is concerned.*" This of course is true; it is a truism. If the orange is not acting on any of my senses but thát of vision, neither its taste, touch, or smell can be actual, *so far as my consciousness of them is concerned.* The important question, however, is this —Is the orange not there to affect the first *bonâ fide* nose or tongue or fingers which are applied to it? It will be easy to convince any one but a willing idealist that this is the best way of solving the question. The Professor continues :—

"A sensible thing, say an orange, means to us a group of conceivable sensations, not only visual but tactual, and of taste, smell, etc., guaranteed to us by the perceived sensations with which it is associated, and which sensations will follow in guaranteed order, according to a law of nature and of our mind." This is putting the real into its ideal form, and its ingenuity every one will admit.

The Professor, in reviewing Berkeley's "Theory of Vision" —a theory, we may say, which many years ago we read with objects not metaphysical but scientific, and which in this light commended itself at once to our acceptance and

admiration,—on reviewing this theory, the editor takes occasion to enlarge upon Berkeley's idealistic theory of physical being, as if the laws of vision, as explained so well by Berkeley, afforded sensible confirmation of idealistic notions. Berkeley's theory of vision assuredly does nothing of this kind; on the contrary, vision affords us the strongest confirmation of our natural belief in spacial externality, seeing that it presents us with extended phenomena.

"The signs given us in vision," remarks Professor Fraser, "guarantee us certain tactual sensations when the necessary conditions are fulfilled."

(*Remark.*) Of course they do, says the realist, the necessary conditions being our *touching the object.* No, says the idealist, the necessary conditions are wishing and experiencing locomotive and tactual ideas.

"We are apt," continues the commentator, "to take for granted that we can see and touch the same immediate object of sense. There is an orange on the table, we spontaneously say that we at once see it and touch it. But this *it* conceals what might carry us to the heart of things, seeming to imply that we see what we are touching, and touch what we are seeing. Now, the visible extended sensations which we perceive have nothing in common with the hard resisting sensations which we perceive when we are touching an orange; coloured extension is antithetical to felt extension."

(*Remark.*) If an orange is an aggregation of different sensations, we certainly cannot touch what we see, or see what we touch; but this is a mere playing with the question. The commentator must see very clearly that the fact of the nature of the sensations of sight and touch being distinct, affords no argument against the corporeal existence of the external objects; the sensations of touch, sight, taste, and smell differ from each other, but can the Berkeleyan philosopher assign any reason why an object which affects us with the *visual* sensations should not be able also to affect us through the fingers with the sensations of touch, and through the tongue with the

sensations of taste? If he can do this he will greatly strengthen the argument for the theory we are considering; but till he does so he may as well argue that because an orange is round, it cannot be sweet, or because the mind perceives yellow, it cannot solve a mathematical problem; or because it remembers a fact, it cannot exercise volition.

"We cannot," says the commentator, "we cannot touch the orange of mere sight, we cannot see the orange of mere touch." [Is the word *mere* put in here inadvertently, or advisedly?] "We connect them under the same name, indeed, but is not this after we have had experience of each sensation, and that they are companions. Thus, in this curious life of ours, in the sensible world, tangible things are signified by visual sensations, and visible things by tactual and locomotive sensations."

(*Remark.*) It is surely not meant that as we never have the companion tactual sensations of the sun, the moon, the stars, the rainbow, and of various other sensations, therefore we must conclude the visual sensations to be abnormal and deceptive.

"Berkeley's 'Theory of Vision,' then, is a reasoned defence of the proposition, that what is called seeing the externality, distance, figure, and size of a real thing, is truly interpreting the visual signs with which real externality, distance, figure, and size are arbitrarily but universally associated."

We demur entirely to the statement that the visual and the tactual signs of figure, size, distance, are *arbitrarily* associated; the quality of the various sensations of vision and touch, *as feelings*, are, we admit, arbitrary, but not so the *facts* and *ideas* embodied in them. Though the presentations, or images, which these senses bring before the mind, are independent one of the other, yet each of them affords corroborative evidence of a real extended object, and each of them is significant and intelligible, and therefore true and absolute in its nature; each presents to the mind an extended

object, which may be understood and reasoned on (*i.e.* whose bulk, distance, and figure may be subjected to the laws of geometry). All the laws of this science which deals with these physical properties of bodies may, *through vision alone*, be perfectly well studied and understood, and, on the other hand, there are instances of persons born blind who, *through touch alone*, have become expert geometers, and have understood the same laws as those revealed by vision. How is this? Simply because these laws of figure, size, and distance applied to any object, are in themselves not arbitrary, but real and absolute, whether studied through touch or through vision. In other words, the concurrent testimony of sight and of touch is not an arbitrary concurrence, but each sense presents us with knowledge which is one and absolute as the laws of mathematics.

We have dwelt on Berkeley's views because we observe in our day, and in our country, something like a growing fondness for these opinions, to the great injury, as it seems to us, of all sound philosophy.

When we first, now many years since, perused the philosophical writings of this most attractive author, we were captivated by the beauty of his language and by the mystic grandeur of his theory. When vision, for instance, was represented in the light of a discoursing of Deity with the souls of his creatures, what idea could be conceived more sublime, and the more so because the man who believes in the constant presence of Divine power in nature must see that the idea contains a substantial element of truth in it. The moment, however, that we endeavour to work out Berkeley's theory in detail, in accordance with the denial of the spacial externity of the world, it appears so subversive of the convictions of consciousness and of reason, that we experience no hesitation in at once rejecting it. Deity does discourse with man in nature, as Berkeley alleges, but then it is in, or through, those extended physical agencies which exist around us.

There are various ways in which we may treat a theory so famous as this one of Bishop Berkeley. We may regard it as a pleasing fiction serving to gratify the imagination of the reader, or we may admire the spirit and eloquence of the language, or we may study, and with profit, the ingenuity of the arguments employed ; or, lastly, knowing the place it has occupied in philosophy, and how many readers have acknowledged the apparent cogency of the arguments, we may deal with it seriously, with a view to discover the true value of the arguments employed.

The first questions of a neophyte are naturally these :—

Is this a more probable theory than the one commonly received ? Are there philosophical objections to the prevailing belief in externality ? Has Berkeley any substantial ground on which he bases views so subversive of our natural convictions ? To all such practical questions we in vain look for an answer.

Coming then to a closer examination of the subject, and admitting the premisses to be rational, namely, that sensation is the affection of a spiritual principle called the mind, we inquire : Are there any grounds to induce us to reject the teaching of the sensations as interpreted by the mind? The reader of Berkeley will in vain look for any such. Surely it is a strange position to assume that man possesses nothing but sensation. Man is not merely a sensitive mollusc, as Berkeley for his own purposes represents him; he is a being conscious of possessing active energy and power, and the means of making these available ; and he gives proof of his connection with an extended world by his constant dealings with it, and by the permanent impressions which he makes on it. The cities, railways, bridges, temples, and the waving crops which cover the earth's surface, tell how efficient is his agency. No theory which gives the lie to our natural convictions, and which denies the spacial externality of the world, can be accepted without some reasonable recommendation, and we find none such offered.

The theory was a pleasing and ingenious fancy, congenial to the author's temperament, and which afforded him a refreshing retreat from the materialism of his day, it however hangs on no peg, it possesses no visible foundation; its strength, like that of all puzzles, rests simply on the terms in which it is presented to us. We admit that they who accept the premisses without challenge, will not easily escape from the conclusions to which Berkeley draws them. We have already stated, however, that the premisses are pure assumptions which are not only not to be accepted *in the form in which they are put*, but which are, on the contrary, to be rejected as both incredible and unthinkable.

Berkeley's argument is founded on the assertion that the mind is a spiritual, intangible principle, and that it deceives us. Now, while most men believe the spiritual theory of mind, they yet acknowledge that it is founded merely on an inference, or probable judgment. Such being the case, and seeing we have no knowledge or consciousness of the mind's essential nature, as distinct from extended physical existence, it is evident we are not justified in employing the theory for the subversion of the stronger facts of consciousness; on the contrary, when opposing Berkeley's destructive theory, we are entitled to say that while we are conscious of an external world, we are not conscious of the true nature of the mind, and that any inference which we may form regarding this can never be employed to set aside the facts and phenomena of external nature—the figure, extension, and motion of which we are conscious.

In the second place, we charge Berkeley with the attempt to impose a still heavier tax on our credulity, in requiring us to believe that what comes to us with all the credentials of truth, is not only to be ignored, but is to be regarded as false. Berkeley's position is equivalent to first assuming man's possession of an intelligent, spiritual principle, and then assuming it to be necessarily unintelligent, irrational, and untruthful.

Lastly, the theory is inconsistent with reason; because to ask us to believe that anything, whether physical or spiritual, exists, and yet occupies no space, is to ask an impossibility. It is equivalent to denying the existence, not only of the physical world, but of the soul, of God, of force, of motion, of action of every kind; Berkeley, therefore, as we have said, asks us to believe a theory which is unthinkable.

Berkeley objects to the ordinary conceptions we form of matter as an entity, self-dependent, and therefore eternal and indestructible, a thing insensible in itself, yet possessing all the properties or powers which enable it to conduct the laws of nature. In this we concur with him. And when he says that we perceive nothing which explains the existence of power in bodies, we also concur; but when he says that we see no connection between one event and another, which can account for the one following the other; that we see one event *succeeding* another in a regular and constant sequence, but we see nothing connected with the bodies to account for this,—to this we refuse our accord. We shall make some brief remarks on these several positions.

In the first place, then, we repeat that Berkeley's objection to matter as an insensible but self-dependent thing, is an objection to the force of which we give our entire concurrence.

Reason can form no satisfactory conception of matter in this light, nor account for such a thing acting, as it does, apart from reason and mind.

Berkeley's next objection we consider partly right and partly wrong; it consists, in fact, of two entirely separate positions, which are not sufficiently kept apart by metaphysicians. The first position is, that in physical bodies we discover no cause for the energies they are supposed to possess. In this proposition we fully concur with Berkeley, Hume, and others. We discover by our senses no cause which may explain attraction or any other of the energies which are inherent in nature. But Hume, Berkeley, Mill, Fraser, and

many others go far beyond this. If we understand them aright, they assert that we discover nothing connected with physical bodies capable of explaining the physical effects which we daily see them producing; in other words, we discover in the operations of nature and of common life nothing but a certain unmeaning, unintelligible sequence of events. This position has always appeared to us so contrary to experience, that we set it down as absolutely and ridiculously untrue.

It is clear enough, as we have said, that we discover no cause for the existence of active power in physical bodies, but, accepting their power as we know it to exist, and as impressed by the hand of the Creator, surely this enables us to understand the connection which exists between physical events. If any man does not see this connection, then such a man cannot be endowed with the ordinary human faculties. I hold in my hand a dish of milk; the substance of the dish, its parts, are held together by a power of cohesion which is one of nature's laws. This is a power which I perceive, although by the senses I cannot discover its cause; the cohesion of the dish, however, and its peculiar shape, enable me clearly to understand how it preserves the milk from falling to the ground; this is therefore to me an *intelligible* instance of cause and effect. Now, by an exercise of volition, I overcome the power of cohesion; in other words, I break the dish. Part of it I hold in my hand, the other part falls to the ground, and as a perfectly *intelligible consequence*, the milk is lost.

What we say, then, is, that any man who admits the power of gravity, and who yet denies the necessary connection between the breaking of the dish and the loss of the milk, must view the matter in a light which to us is unintelligible.[1]

[1] Dr. Hutchinson Stirling, with an exuberance which we cannot imitate, illustrates these views: "Let the reader fully realize to himself what the assertion means, that the cause A is only an invariable *first*, and the effect B only an invariable *second*. We have but a fact before us, we know not how, or whence, or why; we have absolutely *no reason* whatever for the fact. The succession *is*, *has* been, *may* be: but it is a *dry* fact of mere succession. But for the order in time, they are not one whit more connected, the one with the other, than this ink bottle and yonder coal-scuttle. It is really a mystery how the key fits the lock, or why

This simple instance will apply to every other intelligible physical event. We have touched on the subject of the connection of physical cause and effect, not so much because Hume, Berkeley, or any other idealists have denied any between one event and another, but because Professor Fraser would seem, if we understand him aright, to assert this to be an established doctrine of modern philosophy. (See Berkeley's Works, p. 407.) "Causality in the external world," says he, "is neither more nor less than regularity of succession; there is no efficiency within the vast organization of sensible things. This resolution of physical causality into bare invariableness of coexistence and succession is now a familiar analysis in the modern account of the objects and limits of all purely physical inquiry."

To this we reply, if physical force is not perceivable or provable, then all events are loose and unconnected; but if we are conscious of the existence of physical power, then are we conscious of the connection between cause and effect in ordinary physical events, and the world is to us, so far, an intelligible world, in which reason and science may work cordially hand in hand.

But, again, as to externality, some authors, and we need only allude to Kant, Ferrier, and Lewes, assume that though the external world exists we know nothing about it. Do these authors mean to say that what appears a straight line may be a crooked one, and what appears a circle is perhaps a square? Do they suppose that the world may possibly be triangular instead of round? We would like much if these writers would condescend to instruct us in their meaning, instead of framing sentences so hopelessly broad, loose, and

Bruce's Calthrops overthrew the English horse. To varnish an egg preserves it, but we are not left with the naked fact only, we can give an account of it as well. If I turn a turtle on its back, you do not wonder at its remaining so; you do not draw your boots on with a pair of skewers, and you do not say the only reason why not is that boot-hooks are the invariable antecedent. The same breath that cools your soup will warm your hands; but in neither case is the *first* to the *second* only a *dry* one; it brings *foison* with it, and the virtue which connects them." (As *Regards Protoplasm*, 1872).

unintelligible. Do they mean that a wall has no resisting properties, and that fluids have no mobile particles? Mr. Lewes holds it to be certain that the world is entirely unlike what we suppose it to be; Kant denies that it occupies space; Ferrier says that because perception is a synthesis of self and non-self, therefore neither man nor angel can possibly understand anything connected with external nature. If this is the case, we beg to ask, how is it that we come at all to believe in the existence both of an Ego, and of a non-Ego? How is it that the sentient Ego does not uniformly deny the existence of the unknown and insensible *non-Ego?* Why is the *compound* not all in all? How is it that we talk of the laws of physics and the laws of mind, as the laws which regulate two separate and distinct factors? How do I know that I hold a pen in my hand? How do I know that the pen is not a part of myself, *i.e.* of my mind, and yet such knowledge I seem to have, in spite of this overpowering synthesis of which these writers speak?

Hamilton, of all men, has, from want of a very little care, slipped into the same blunder. "Suppose," says he, "that the total object of consciousness in perception is 12; and suppose that the external reality contributes 6, the material sense 3, and the mind 3, this may enable you to form some rude conception of the nature of the object of perception." ("Lectures on Metaphysics," vol. ii. pp. 125–128). This is all very well in speaking of the secondary properties of bodies, but as it is given, it is an exceedingly loose and unbusiness-like statement, confusing our notions and tending to subvert his own theory of perceptive consciousness.

The truth is philosophers have been unaccountably careless in this inquiry. Had they insisted on keeping distinct what is purely subjective in our sensations, and the knowledge which is provably derived from the external object; in other words, had they kept what concerns the form or figure of visual and tactual presentations apart from the mere *colour or quality* of the sensations, they would not have allowed the

subject to become involved in the confusion into which Berkeleyans have thrown it.

The *real* properties of matter are its figure or extension, mobility, solidity, and other resisting properties. These are all that, on any supposition, we could expect the senses to reveal to us; and in our visual and tactual sensations we have no difficulty in keeping these distinct from the other more secret inherent properties which reveal themselves to us.

In a question regarding physical reality, it is evidently of no moment what the quality of the sensation is. It is for instance of no importance whether the sensations which reveal the figure, size, and motions of the book which I hold in my hand, are red, brown, black, or blue. The reality of the book does not depend on the quality of the impressions. The fact of real importance is that the sensation should carry impressions of the physical properties of the book; and in objecting to the reality of this knowledge, a Berkeleyan in the present day will not be allowed to assume, as was done in the days when a scholastic dogma came in the place of of science, that the mind is unextended, and so cannot be affected by extended impressions. All we know is that extended objects will impress an extended brain with extended action, and that extended sensational phenomena will result.

If the Berkeleyan says it is not the book that I perceive, but an idea in my mind, I reply, that I do not *perceive an idea*, but I feel sensations or impressions, tactual and visual (the latter may be brown, blue, or any other colour), of the form of the book, and I perceive that if I move the book the impression moves relatively to other visible objects.

That a man should, from idealistic tendencies, take the heroic step of tossing the world overboard, and retaining only what he calls the ideas existing in his mind, we can in some measure comprehend; but that any individual should admit an external world, and of course external organs of sense, and should prosecute perhaps the calling of an engineer,

or a land surveyor, and yet disbelieve his own angles, curves, and straight lines, is what we cannot comprehend.

"I am conscious," says Mr. Lewes (" History of Philosophy" pp. 154, 155), " of all that passes within myself, but I am not conscious of what passes in non-self; any knowledge we can have respecting *non-self* can only be formed by inference.

" Thus, I burn myself in the fire, I am conscious of the sensation, but *I can only be conscious that a change has taken place in my consciousness:* when from that change I infer the existence of an external object (the fire), my inference may be correct, but I have obviously shifted my ground, I go out of myself to infer the existence of something which is not self; my knowledge of the sensation was immediate, indubitable, my knowledge of the object is mediate, uncertain." He might have added, though it has form, position, motion, and power.

And again, " Perception is a consciousness of changes operated in us, not a consciousness of the objects causing those changes. In truth, so far from our being able to apprehend the nature of things external to us, there is an impenetrable screen for ever placed before our eyes, and that impenetrable screen is the very consciousness upon which Descartes relies." (p. 105.)

Here is a strange conclusion. It however is not the conclusion of Berkeley, and we allude to it here merely because some, who are not idealists, but persons professing to believe in an external world, yet hold Berkeley's chief argument to be indubitable, that because we possess no knowledge of anything except what the mind reveals to us, therefore we have no reason to suppose we can form a single reliable judgment regarding external things.

It would be instructive to know how it comes to pass that writers on philosophy have reached this conclusion. The mind seems to reveal natural phenomena to us clearly and consistently, and yet they assume it to be untrustworthy, even in the most ordinary and every-day particulars, not knowing

of the existence of the fire that burns us, or of the house in which we live.

We at once admit that when man ventures to dogmatize on the essential nature of matter he goes beyond his powers. This does not arise, however, from any defect in the senses, nor yet because of the constant presence of the misleading *self-element*, supposed by Professor Ferrier and some other writers to stand in the way of knowledge, but simply because man only knows matter by its effects on his body, and through it on his mind, and because his knowledge of the primary properties, which embraces all we know of matter, extends only to those relations which are common to extended bodies, namely, to their figure, size, solidity, motion, etc.

It is evidently vain for finite beings living under such circumstances to imagine that by the senses they can penetrate into the nature of *absolute being*, either physical or spiritual. The inner nature of all things depends on the nature of their great Cause, and His essential nature we must be content to accept as a mystery lying beyond our powers of comprehension.

But while we are willing to admit the philosophy of ignorance into our creed in matters transcendental, it appears equally important that we accept the facts of our consciousness as they are given us in matters terrestrial.

To distrust our faculties when they are exercised on the realities of the world with which we are in contact, to cast out one part of our consciousness and to retain another, simply on the strength of an assumption of our own devising, regarding the nature, powers, and properties of the mind, seems to us, of all things which we have met, to be the most contrary to the principles of sound philosophy.

And now, in parting with Bishop Berkeley, we confess to a certain feeling of self-condemnation; for while we have always experienced the warmest admiration for this singularly attractive writer, we have never lost any opportunity of doing what we could to discountenance and discourage his ideal theory.

We do not find that we can now conscientiously abate one single stricture which we have urged against it; but for our own individual relief in parting, we now say, with the most perfect sincerity, that we both hope and believe that this most ingenious writer will prove as attractive and as instructive, to the minds of readers in future generations, as he has been to those who have preceded our days. Berkeley deserves this. Notwithstanding his attack on the world in which he lived, he has made his mark on it more than many who have assiduously courted and embraced it; and his genius has obtained for him a place in the fore-ranks of literature, philosophy, and science. He has, no doubt, puzzled a few of his admiring friends, and led them into dreamland; but, in spite of this, we are bound to confess that his writings will be found to afford the intelligent reader more pure, intellectual enjoyment than perhaps those of any other philosophical writer. They are, moreover, singularly healthy and buoyant, and therefore we need scarcely add that we nowhere discover in them any trace of those distressing and disturbing influences which, to the unenlightened, the loss of a physical world might be expected to produce.

CHAPTER XXXV.

KANT.

WE shall now close our slight critical sketch of the views of certain of the chief leaders of philosophical opinion, by presenting the views of one of the most illustrious of modern thinkers, so far, at least, as these concern us and our subject, and as we are enabled to understand them.

Immanuel Kant was born at Königsberg, in Prussia, in 1724; he settled at the university of his native town in 1755, and there, for fifteen years, he occupied himself as a private lecturer.

In the year 1770, at the age of forty-six, he became an ordinary professor of logic and metaphysics in the same university; and in this position, as a laborious and successful teacher, he continued till 1797, when the infirmities of age laid an arrest on the further prosecution of his professional duties. Such are the brief records of a life so eminently influential as that of Kant.

He died in 1804, in the eightieth year of his age. His habits of life were singularly simple, quiet, and laborious. It may give some idea of the uneventful character of his outer life to know that he never once journeyed beyond the bounds of his own native province. Well then has he earned the title by which he is so well known,—the sage of Königsberg.

The Germans are undoubtedly the most indefatigable and laborious literary and scientific people in Europe. The love of learning is with them so much a ruling passion, that they too often unduly parade even the outward show of it. In the enthusiasm with which they plunge into abstruse subjects, they frequently shut their eyes to all but the one object of

pursuit, and thus they neglect to arrange the valuable materials which, with extreme toil, they excavate. This may account for the loose and unartistic character of many of their most important writings.

Then, again, we have to remark the frequent evidence of imaginativeness which pervades their philosophy, no less than their poetry and fiction, and which affects the marvellous, the uncertain, and the extravagant. As historians, we accordingly find they tend towards scepticism; in religion, they pass out of it into a misty cosmoism; in medicine, they rest their faith on infinitesimals; in philosophy, they float into nihilism. It is only in chemistry, physiology, and other physical sciences, where seeing is believing, that we find them resting on sound and reliable ground. These remarks are, perhaps, too little qualified, but we wish the reader to judge for himself how far the character we have assigned to the Teutonic nation asserts itself in the author to whose philosophy we are now about to direct his attention.

Kant's great work, "The Critique of Pure Reason," appeared in 1781, when he had attained 57 years of age. A few words regarding the circumstances which seemed to have called forth this remarkable and important philosophical effort.

Locke had denied the existence of innate ideas, maintaining that all our knowledge was derived from sensation and the internal sense which he called reflection.

Hume had challenged a proof of the existence either of mind or matter, of the connection of cause and effect, of the existence of power, and of the being of Deity. It was with a view then of examining the foundations of human knowledge thus variously attacked, that Kant, in his advanced years, as the result of protracted cogitation, prepared his elaborate work, "The Critique of Pure Reason."

Taking his stand upon the great fundamental truth, that man possesses a rational thinking principle, and that this principle acts according to fixed, unvarying laws, Kant shut himself up within the world of mind, resolved to study these

laws, and to show how far Locke was at fault in denying the existence of innate ideas, and how far Hume erred in representing the mind as a mere bundle of ideas held together by some vague, natural affinity, or by the laws of a varying experience. Kant undertook to demonstrate that the mind possesses laws of its own ; that its forms of thought are inherent and necessary, and are not the result of outward experience, and that our sense perceptions, our conceptions, and our judgments are all moulded and determined in accordance with the original laws of mind. We must not imagine that the doctrine, that the human mind acts according to fixed laws was an original discovery made by Kant. This great fact was recognized long prior to his time—we may date as far back as Aristotle, and nowhere, in more modern times, had mental psychology been more ably handled than in our Scottish school. That Kant, however, subjected the elements of human thought to a more searching scrutiny than had ever previously been ventured upon, and that he threw additional light and interest upon some parts of the subject, we freely and willingly admit. His main effort, however, was different from that of any of his predecessors—it was transcendental ; it attempted to discover the pure ideas which remain in the mind after all that comes from without is deducted, and thus to find what is contributed by mind and what by externals.

It seems to us that in this transcendental effort it is more the genius and daring which prompted his method which is to be admired, than any signal success which attended it. The question must present itself to every sober-minded Englishman, whether in prosecuting this transcendental analysis of the mind, Kant did not attempt what lay beyond the limits of the human faculties, and whether by the conclusions to which he was led, he did not arrest the progress of philosophy by drawing it into depths and errors from which it has not yet emerged. His object was one of the noblest we can conceive, provided it were a practicable object, and this had to be ascer-

tained. Any way, the man who devoted his life so manfully to so high an effort is entitled to our gratitude and admiration. The effort, however, to establish the laws of pure mind by eliminating the elements supplied by the senses, in the way attempted by Kant, has always appeared to us a self-delusion; and in reading Kant's famous work, while we recognise his subtlety as an analyser of the operations of the mind, we find constantly, when he comes to apply to those mental operations his transcendental test, it is here, at the critical point, that his method breaks down, that he becomes illogical, that, to put it in plain words, he assumes the point to be proved. His process seems to us not even to have the merit of the professor of legerdemain, for Kant takes us into utter darkness, and while we are thus deprived of the natural exercise of our faculties, he then and there assures us that the transformation is accomplished, and that his position is proved. Lest this should be thought a harsh censure, we bid the reader remember that, as regards the idealistic conclusions to which Kant thus arrives, not one man in ten thousand is found willing to acknowledge his trust in the proof which has been offered.

Kant tells us, in the preface to the second edition of his great work, that, dissatisfied with the pretensions of metaphysics and its constant failures, and more immediately by the attempt of Locke to establish a sort of physiology of the human understanding, and to found knowledge on the ground of common experience or sensation, he had felt called to undertake the establishment of a tribunal which might secure reason in its well-grounded rights—that this could only be accomplished by discovering and fixing what are reason's own eternal and unchangeable laws. Kant accordingly undertakes a critical investigation of the laws of pure reason, and of the mind in the discharge of its various functions. His aim in this is to set forth systematically and exhaustively both the contents and faculties of the mind, its subjective laws, or natural modes of working, its intuitions, its cognitions, and

conceptions, as these exist within it, apart from what is imparted by the senses. Also to examine what conceptions, or forms of thought, *à priori*, are given us by *reason* as the highest function of the mind. If this can be accomplished, we have the prospect, says Kant, of greatly extending our knowledge in various ways, both as regards the nature of the mind and the nature of the external objects of sense.

Metaphysic, says Kant, is that which deals with our mere conceptions; and in studying these, reason must necessarily be constituted at once its own pupil and examinator. Why, says Kant[1] (preface, 2nd edition, pp. 28, 29), has metaphysics been so contradictory, why has no progress been made? Perhaps, says he, we may be able to explain this. It has hitherto been assumed that our *cognitions* must conform to the *objects*, and we have failed in our metaphysical inquiries; let us therefore alter the experiment, and try whether we may not be more successful if we assume that the *objects* must conform to our *cognitions* of them. This method, says he, seems to accord better, at all events, with the possibility of our gaining the end in view, and arriving at the cognition of objects *à priori*, and determining something with respect to these objects before they are given us. When Copernicus found that he could make no progress by assuming that all the heavenly bodies revolved round the spectator, he reversed the process, and tried the experiment of assuming that the spectator revolved, while the stars remained at rest. We may make the same experiment with regard to the intuitions of objects. If we must hold that the intuition or representation furnished by sense conforms to the nature of the external object, I do not see how we can know anything of them *à priori*. If, on the other hand, we hold that the object conforms to the nature of our faculty of intuition, I can then easily conceive the possibility of such *à priori* knowledge.

(*Remark.*) If we can prove that the object is made by the mind to bend as it were from its true nature, in the mind's

[1] The Critique, translated by J. M. D. Meiklejohn. Bohn, 1860.

cognition of it, we must, indeed, accept the mental conception as an *à priori* conception. But, query, how are we to ascertain whether or no the object so bends; and, if it does, how far it bends from the form of the external reality?

Again, says Kant, as I cannot rest in the mere sensations, or sensational intuitions, but, if these are to become cognitions of the mind, must refer them, as *representations*, to something as objects which they represent, and must determine the object by means of the representation, here again, in the exercise of this higher function, there are two courses open to me. Either, first, I may assume that the conception by which I effect this determination conforms to the object, and in this case I am reduced to the same perplexity as before, *i.e.* I am not able to ascertain the *à priori* elements; or, secondly, I may assume that the objects or, what is the same thing, my experiences, in which alone, as given objects, they are cognised, conform to my conceptions, and then I am at no loss how to proceed.

We have in these passages, which we have somewhat simplified, the kernel of Kant's philosophy shadowed forth; and there perhaps never was a more bold and adventurous principle hatched by philosophy. It is difficult, indeed, to determine whether Kant felt any confidence in the principle on which he was to found and work out his inquiry in laborious detail, or whether we are to view his work in the light in which he describes it, as an experiment in order to see to what conclusions it might bring him. Or may we not view it as an undertaking entered upon chiefly to amuse his highly abstract and metaphysical nature?

Kant, we shall find, experiences no hesitation in assuming at once, that the objects, and what is the same thing, the representations which the senses give us, and which, as in the above passage, he calls *our experience*, conform to our conception of them; and to explain what we make of them he supposes *à priori* laws of the understanding which are expressed in conceptions *à priori*. To these conceptions,

then, all the objects of experience must necessarily conform, and we only cognise in things *à priori* that which we ourselves place in them. Kant's conclusion leads practically to this, that our knowledge is purely subjective, and we have no knowledge of reality. This, strange to say, is the leading aim and object of Kant throughout the whole first and larger portion of his work. To show that the mind has laws of its own, irrespective of external experience as to physical objects, and that in our own higher conceptions regarding the existence of God, the freedom of the will, and the immortality of the soul—as these are all moulded by the mind, according to the mind's subjective laws—they want the impress of real knowledge.

Let us here note the object which Kant had prominently before him while working out these conclusions ; and if we shall not be able to join with him in rejoicing at the abandonment of all possible human knowledge, we may at least be able to approve the ultimate aim he had in view. Kant, by thus endeavouring to prove the total impossibility of human knowledge, considers he thus, and thus only, can deliver philosophy from certain otherwise insoluble metaphysical difficulties. Such, for instance, as those which meet us when we affirm the existence of a *Being uncaused*, and of a world either *created* or *eternal*—the conception of the *freedom* of the will, in connection with a belief in the laws which bind the moral and the physical world—and other great questions of this kind. "I must," says Kant, "abolish knowledge to make room for belief." This is an heroic determination, but the price paid seems to us a very heavy one, and most men will grudge it : for Kant's belief in all these important points which we have mentioned is not an absolute belief, but the mere possibility of a belief. Surely we may retain as strong a belief in these cardinal points, by a simple admission of our inability to reconcile the metaphysical difficulties which emerge when a finite mind endeavours to deal with the infinite and absolute and necessary, without a total surrender

of all human knowledge, physical and spiritual, temporal and eternal, human and Divine. Kant prefers to solve the problem, and preserve the walls from the occupation of the enemy, by blowing up the citadel.

In the passages quoted, and in others to be quoted, we shall see that Kant raises the question, not merely whether external objects agree with the sense representation of them, but also whether the conception we form of an object agrees with the sensational representation. This latter must appear to most men a very unnecessary question; for surely no one ever before doubted that the passive mental impression, and the conception which we form of that mental impression by the action of the understanding, must substantially agree. If the sensation or impression, for instance, is of a circle, or of a square, or of a triangle, the conception or perception will certainly be of these figures and of no others; and the same of all the other sensations and perceptions of the objects of sense. If, for instance, the mental impression, or intuition, as Kant calls it, is of red, or blue, or yellow, so also will our conception or perception of these be.

But let us proceed with the argument employed by Kant to justify the course he adopts, of assuming that the object conforms to the mental conception.

"Before objects are given to me," says he, "I must presuppose in myself laws of my understanding which are prepared to express themselves in determinate conceptions; to these conceptions, then, all the objects of experience must necessarily conform."

(*Remark.*) Why, we ask, not rather regard the mind as an intelligent principle, capable of forming a true cognition of the objects or representations brought before it?

"From this deduction of the faculty of *à priori* cognition," continues Kant, "we derive a surprising result, for we come to the conclusion that our faculty of cognition is unable to transcend the limit of possible mental experience. The estimate which we must therefore form of the nature of our

rational cognition *à priori* is that it has only to do with *phenomena or mental images,* and that things in themselves, while possessing a real existence, lie beyond its sphere, and we can put the truth of this to the test, both as regards the understanding and the reason. Man feels himself constantly compelled by reason to inquire into the nature of the unknown and unconditioned, into that which underlies phenomena. Now, in doing so, when we assume that the real object, or thing in itself, agrees with our conception of it, we constantly find that the object cannot be so thought without insurmountable contradictions emerging. This circumstance therefore forces on us the conclusion that our cognitions do not conform to the thing in itself, but that the objects, or representations, present to the mind are phenomena which conform to the laws of our mental representations of them. Considered in this light there ceases to be any contradiction; for if we assume our entire ignorance of the real and unconditioned, no contradictory judgments regarding the real objects can arise. For instance, under the operation of this new interpretation of nature, the operation of cause and effect, as we usually apprehend it, vanishes, and all the other extensive class of contradictions and difficulties involved in the conception of the infinite in time and space disappear,—the infinite divisibility of matter, the eternity and the creation of the world, liberty and necessity, free will and law, God, the soul, and such like. We avoid all difficulties and contradictions on such subjects by acknowledging our entire ignorance of their real nature and existence.

Kant very honestly remarks here that a cursory view of his work may lead to the conclusion that its use is merely negative; but, says he, its use will be apparent, if we find that after infinite previous speculation it serves to confine reason within its proper bounds.

When, for instance, we fix in our mind that space and time are only forms of thought, the former being the form of our sensible intuition, and the latter the form of our internal

consciousness, and that they are hence only conditions of the existence of things, as phenomena, we can never be surprised by the discovery that our conceptions of them, as external realities, involve contradiction.

In his introductory chapter, Kant, as if to show that his aim is a challenge to Locke, opens by this clear, simple, and important announcement: "That all our knowledge begins with experience there can be no doubt, for how could the faculty of cognition be awakened into exercise otherwise than by means of objects which affect the senses, and arouse the understanding to activity, leading it to compare, to connect, or to separate them. But though all our knowledge begins with experience, it by no means follows that all arises out of experience; on the contrary, it is quite possible that our empirical knowledge is a compound of that which we receive through sense impressions, and that which the faculty of cognition supplies for itself—sensuous impressions—giving merely the *occasion*. It therefore becomes a question which requires close investigation, whether there exists a knowledge which is altogether independent of sensuous impressions." Knowledge of this kind Kant calls *à priori*, as in contrast with that which is empirical, or *à posteriori*.

Having thus premised, Kant enters methodically on his work; and, first, he undertakes the investigation of that which in our sense intuitions, and in the conceptions we form of these, belong to the *matter* of the intuition, and that which belongs to the *form*: the former he calls empirical, as being furnished by the object, and the latter *à priori*, as being supposed by him to be furnished by the mind.

(P. 3.) The criterion of a judgment being pure, or *à priori*, says Kant, is that it is *universal* and *necessary*. Such, for example, are the various propositions in pure mathematics, and such, as another instance, is the proposition *every change must have a cause*. Such judgments as these, says Kant, are not derived from experience, they depend on the laws of our mental constitution, for they satisfy the criterion, and have

the element of universality and necessity in them—they are not dependent on experience, which is always limited and uncertain.

(P. 4.) But not only do judgments of this sort rest on an *à priori* basis—even in the conceptions we form of the objects of sense there is an *à priori* element constantly manifest ; for instance, if we take away from our conception of a body or object all the elements that can be referred to mere sensuous experience, such as colour, hardness or softness, weight, even impenetrability, the body will vanish, but the space element will remain. This it is utterly impossible to annihilate in thought. And in the same manner, if we take away all our empirical conceptions of any object, corporeal or incorporeal, there still remains the conception of *substance*. From this we must therefore conclude that the belief or conception of space and of substance has its origin in the mind, and is therefore *à priori* a cognition independent of experience or sensation.

(P. 4.) Then, again, regarding the *à priori* conceptions of Reason, that higher faculty of the human mind,Kant remarks, we find there are some very remarkable *à priori* conceptions connected with the operations of this faculty—such are our conceptions of God, of the soul, of freedom of will, and immortality; these rise far above the sphere of all possible experience, and a most important inquiry therefore arises regarding the strength, validity, and worth of such conceptions.

From facts such as these Kant is led to conclude that there must be a science which may be called the *Critique of pure Reason*, whose province is to investigate the principles which this higher faculty gives us *à priori*. The aim of this transcendental science must be to place before us a complete enumeration of all the conceptions, or synthetical judgments, which pure reason furnishes, and from whose pale every conception which contains aught empirical must be rigorously excluded.

Kant then proceeds to classify the various conceptions which the different faculties of the mind evolve. These he ranges thus. He begins with the more humble faculty of receptivity or sensibility, what he calls the æsthetic faculty; next after this he places the faculty which he calls the understanding (*verstand*); and, lastly, he treats of reason (*vernunft*).

(P. 18.) There are, says he, two sources of human knowledge, which probably spring from a common, but to us unknown, root, viz. sense and understanding. All that fails to be treated as falling under the department of sense (and which corresponds with what we in England call sensation, or sensibility), he designates *æsthetic*. The first task in reading Kant is to fix in the memory the meaning of the various terms which he selects to express his peculiar views. These terms are to beginners the source of much perplexity and misconception, for Kant seems not only to rejoice in new ideas, but also in new language to express them.

(P. 21.) Beginning with *æsthetic*, Kant remarks, first, it is clear that our knowledge of objects must be gained by an intuition (*anschauung*); but it is equally clear that the object must exist, and be given to us in order to affect the mind in a certain way. It is due, then, to the capacity we possess for receiving sense representations (*vorstellungen*), in other words to our receptivity, or sensibility, that we are furnished with these representations, and which, inasmuch as we are affected by them, we may call intuitions (*anschauungen*).

It is by a higher faculty, viz. by the understanding (*verstand*), that the sense intuitions are thought out and become conceptions of the mind (*begriffe*). We are to observe, then, as regards the æsthetic faculty, first, that the effect produced by the unknown object or external cause is sensation; second, that the intuition which is related to the object by means of sensation is called the empirical intuition; and, third, that the sensational object is called the representation, or representative object; fourth, that the mental object

as comprehended by the understanding, is designated the phenomenon, or object of experience; and, fifthly, that that in the phenomenon which corresponds with the sensation is called its *matter*,—say red, green, yellow, sound, touch, smell, etc.,—and this is derived from the external object or cause, and is, therefore, *à posteriori* or empirical.' And, lastly, that that in the phenomenon which causes that we can arrange it in certain relations, is called its *form*. It may be the form of a chair, a cube, a circle, or any other form. The form, Kant holds, must be ready in the mind, and be thus *à priori*, *i.e.* it must be furnished by the mind, and not by the external object. So far, then, generally regarding the æsthetic and the understanding faculties in their mutual offices.

Then, further, as regards the faculty of the understanding. If, says Kant (p. 22), I take away from my representation of a body all that the understanding thinks as belonging to it, as substance, force, divisibility, and also all that belongs to the sensation, as impenetrability, hardness, colour, etc., there still remains of the empirical intuition extension and shape; these, then, belong to pure intuition, and exist *à priori* in the mind as a *form of sensibility*, and without any real object of the senses, or any sensation.

By means, then, of our external sense, which is a property of the mind, man represents to himself objects as external and in space.

Regarding time, Kant remarks: "Besides the external sensuous faculty, man possesses an internal sense, by means of which the mind, though it cannot contemplate itself, yet can contemplate its own states as in relation to time."

What, then, asks Kant, are space and time?

First. Are they real existences?

Second. Are they mere relations, or determinations of things such, however, as would belong to them, though they should never become objects of our intuition? or,—

Third. Are they what belongs only to the form of intuition and, consequently, to the constitution of the mind?

Upon this question Kant argues thus. And, first, as regards space:—

Space is not a conception derived from outward experience; for in order that my sensations may relate to something in a different part from myself, and also as out of or apart from one another, the representation of space must already exist as a foundation in the mind. The experience is only possible through the antecedent representation.

(*Remark.*) Might we not with more reason say that the experience is only possible through the antecedent capacity of the mind to receive that experience, *i.e.* to perceive, or be affected by, the extended impression made on the sensorium.

Second. We can never imagine or make a representation, says Kant, of the non-existence of space. Space is therefore apparently the condition of the possibility of phenomena, *i.e.* the condition by which alone we can have terrestrial phenomena. Kant is undoubtedly right here, for physical phenomena without the elements of size and form are not physical phenomena at all, neither can such physical objects exist or be conceived; neither a cube, a house, nor a haystack, nor any extended object, can exist or be conceived unless they possess, and are conceived to possess, length, breadth, and thickness. How could they? We can only form a conception of bodies as possessing their natural properties.

What ground has Kant for declaring that the elements of length, breadth, and thickness are mere mental representations depending on the faculty of the mind's receptivity? This is a gratuitous and most improbable conjecture, and he adduces nothing in its support which can influence any one who is not bent on amusing his fancy with an idealistic notion.

Third. Space, says Kant, is a pure intuition, for we can only imagine space as one and all-embracing, and not as made up of parts and dependent on them. Hence it follows that it is an *à priori*, and not an empirical intuition.

Fourth. Space is represented as an infinite given quantity composed of an infinite number of infinitely large parts. We cannot form an *original conception* of a thing consisting of an infinity of conceptions, but we possess this conception of space; therefore, our original conception of space is not strictly a conception, but an intuition *à priori.*

(*Remark.*) This seems to us an exceedingly objectionable way of stating our conception of space. We have space or size given us with all physical presentations, and extended bodies are just bodies with length, breadth, and thickness—an upper and an under—ends and sides and parts, and other physical properties. And regarding our conceptions of pure or infinite space it seems to us that the conception of this is the conception of infinite nothing—a total absence of any physical body to obstruct the movement of any other moving body.

Geometry, according to Kant (p. 25), is a science which determines the properties of space synthetically and *à priori.* Our representation of space must therefore be an intuition, because from a pure conception nothing can be deduced which goes out beyond the conception; and yet this happens in geometry, where principles are all apodictic or necessary.

From all this Kant concludes that space does not represent any properties of objects, as things in themselves, nor does it represent them in their relations to each other, and which relations would remain with them even if we ceased to perceive them. Space, says he, is the mere form of all the phenomena of sense; it is the subjective condition of that sensibility under which alone all external intuition is possible.

(P. 26.) Now, because our receptivity, or capacity of being affected by objects, necessarily antecedes the intuition of them, it may easily be understood, says Kant, how the form of all phenomena can be given to the mind previous to all actual perceptions, and therefore *à priori;* and how it, as a pure intuition, can contain principles of the relations of these objects prior to all experience.

(P. 28.) Much in the same way Kant argues regarding time, denying its existence, except in the mind, as a form of its internal states. It is the mode, says he, in which I represent myself as an object. But if I could have an intuition of myself without this condition of time, then those determinations which I now represent to myself as changes, movements, or events, following in succession, would present to me a knowledge in which the representation of time and of change would not appear. This seems to us a foolish supposition, unworthy of Kant, for we cannot conceive the possibility of a succession of our own ideas, or any succession of events, except in time. It is the assumption that we should lose the use of reason and the power of thought, and yet still continue to think.

(P. 45.) General logic concerns the laws of thought The transcendental logic concerns only the pure elements or *à priori* forms observed in the intuitions or representations produced in us by the external cause, be that what it may; and, secondly, those which arise in us by the exercise of the understanding employed in forming conceptions on what is given by the passive faculty of intuition. The question to be considered is what, under these two departments, is pure, or derived from the mind, and what is empirical, or supplied by the external object.

First, however, let the reader remember that the mind, having received the intuitional presentation, or *anschauung*, this is, by virtue of a spontaneous function which it possesses, formed into a conception, or *begriff*, and by the exercise of a higher, or at least a more comprehensive, mental power, it is then shaped into a judgment, or *urtheil*. A judgment, says Kant, is the mediate cognition of an object, consequently the representation of a representation of the intuitional presentation. Of the object itself we know nothing.

It would unnecessarily weary the reader to follow Kant's exposition of transcendental logic in his own language, we shall therefore give the mere results as stated in the work of

a Dutch author, who we think gives us the shortest and most intelligible statement of Kant's views which we have anywhere met.[1]

There are in the understanding just as many pure conceptions as there are forms of judgment.

The sensibility furnishes the *matter*, the understanding *the form.*

The judgments of the understanding are comprised under the heads or forms of thought given below, and, as will be seen, each of these heads embraces three classes of judgments.

1. *Quantity.*	2. *Quality.*
a. Universal	*d.* Affirmative
b. Particular	*e.* Negative
c. Singular	*f.* Determinative
3 *Relation*	4. *Modality.*
g. Categorical	*k.* Problematical
h. Hypothetical	*l.* Assertorical
i. Disjunctive.	*m.* Apodictical.

1. *Quantity* (*a*). Universal or general judgments, whether affirmative or negative; such as can have no possible exception, *e.g.*—All animals have feeling; No man possesses all knowledge. Now, says Kant, we could not form any such *judgments* unless our understanding previously possessed in itself the *form* or primitive *conception* of *totality*, by which it forms the conception of *animal* and *man*.

The conception then of *totality*, or generality, is a pure conception of the understanding when the *matter* is cast out from it. And without this power we could not think at all. When we talk of a plant, a man, a mineral, an animal, we exercise this faculty.

(*b*.) Particulars, or plurals, have reference to a plurality of objects considered as a determinate quantity, and particular

[1] Essai d'une Exposition succincte de la Critique de la Raison pure. Par Kinker. Traduite du Hollandais par F. le F. Amsterdam, 1801.

because consisting of a variety, *e.g.*—There are some duties difficult to fulfil; or, There are some animals which only live one day. The pure element here, if we cast out the *matter*, is *plurality*.

(*c.*) Singular, or individual, *e.g.*—Homer was a great poet. The conception here is of individual unity.

2. *Quality* of judgment (*d*). Affirmative affirms a quality belonging to a thing; as, Iron is a metal.

(*e.*) Negative judgments express the absence of any quality; as, A stone has no feeling.

(*f.*) Determinative judgments are such as neither directly affirm nor deny, and yet determine what the object is; thus the judgment, The soul is not mortal, determines that it is immortal.

3. *Relation* of judgments among themselves.

(*g.*) Categorical or positive judgments. Such judgments embrace two conceptions, that of the subject and that of the the attribute, *e.g.*—God is just. In this there are not only the forms of quantity and quality, but also of relation; and we may remark here that we cannot think without employing more than *one* form of thought.

(*h.*) Hypothetical judgments contain two propositions, of which the one serves as foundation to the other, as the the second announces a conclusion flowing from the first, *e.g.*—If there exists a supreme judge, evil must be punished. Here there is a necessary connection; and it implies in the mind the *à priori* conception of the relation of cause and effect.

(*i.*) Disjunctive judgments, where two or more conceptions are so united as that the occurrence of the one excludes all the others, or the denial of the others, is equivalent to the reception of the other one, *i.e.* the truth can only exist in one of the disjunctive propositions.

4. Modality has reference not to the object of thought, as quantity, quality, or relation, but to the relation which our judgments have to the faculty which judges. It differs from the three others which have reference to the objects of our

thoughts. Modality, on the contrary, determines the value of a judgment relatively to the thought itself, or the manner by which the thinker acts in forming a judgment.

Modality embraces, like the other general forms of our judgments, three subordinate forms, in which we shall constantly find the connection of the judgment with the subject mind which judges.

(*k.*) These three are probable judgments, in which the affirmation or the negation is announced as simply possible; as, Perhaps the moon, like our earth, is inhabited.

(*l.*) Assertory, in which the affirmation or negation is announced as an actual fact; as, Man is endowed with reason.

(*m.*) Apodictical judgments, *i.e.* in which the affirmation or negation is announced as being a necessary truth; as, Every circle has a centre.

There can be, says Kant, no form of thought or of judgment which is not comprised within these heads; and in these, if we cast out the matter, or what pertains to experience, or the particular, they will be found to constitute the forms of all possible thought.

To judge, says Kant, is to subsume into a conception, *i.e.* to assign an object to its proper conception. And this can only be done by means of the pure or *à priori* laws of the understanding. They are the rigorous forms of thought; they are not derived from experience, and yet without the perceptions of experience they could no more exist or be brought into operation than a mould could communicate its impression without wax or clay to receive the impression.

Now, our sensible perceptions of time and space are the matter to be assumed into the *à priori*, or pure forms of the understanding; as these forms are made to receive, and render our conceptions conform to the sensibility.

Kant calls the sensible image, or conception of the understanding, a *schema*. Thus the number 3 is the numerical expression of the quantity.

All our judgments, *urtheilen*, then, says Kant, are formed

on and embrace the categories, or pure conceptions, of the understanding, under these heads :—

1. *Quantity.*	2. *Quality.*
Unity	Reality
Plurality	Negation
Totality	Determination

3. *Relation.*	4. *Modality.*
Substance (and accident)	Possibility (impossibility)
Cause (and effect)	Existence (non-existence)
Reciprocity	Necessity (contingence)

This table, says Kant, embraces all the original forms of thought; and the understanding of man is so formed that it cannot act, conceive, or think, except according to these categories or pure forms of thought.

In order to think, we require an object, or the material of thought which is furnished to the understanding by the sensibility by means of its proper forms. While the understanding takes possession of these perceptions, reunites them by means of its own pure forms, and refers them to a conception, while at the same time it has the consciousness of this its operation, this work of the understanding is accomplished by means of the three faculties which accompany it—imagination, reproduction, or remembrance, and self-consciousness.

Kant then announces that, if it is true that we can only acquire conceptions according to the forms of our sensibility, which are time and space; in other words, if objects, whatever they may be, and whatever their qualities (of which we cannot form the slightest notion), cannot produce impressions on our sensibility, except in relation to time and space, and if on the other hand we cannot conceive these objects, except according to the laws of the understanding, *i.e.* according to the categories, then it is evident that all we know of these objects is only appearance, and they are only phenomena, *i.e.* things which appear as they are only by virtue of the laws of the mind.

All perception is very clearly and elaborately shown by Kant to be possible only through our connecting the internal sense of self-consciousness with the external object, and thus reducing the manifold and multiform of every object presented to the mind into a unity of cognition. By this mental process alone, can we become conscious of external change, and by this we are led to form the judgment that amidst all the changes of phenomena there is a permanent substratum, or self-identical substance. From the same principle of self-consciousness in time flows the possibility of belief in the connection of cause and effect, by which the changes in time and place are reduced to order and law, and the principle of relationship, community, and reciprocity is established between objects and throughout nature, in conformity with the categories.

Kant after this treats of those conceptions or ideas which reason forms when she steps beyond the limits of experience. He styles these the transcendental conceptions of reason. They are formed by reason in obedience to a law which urges it for its own satisfaction to seek an absolute unity in all that it contemplates. Such are its conceptions regarding the unity and immateriality of the soul, the totality of the world, the being of God, the freedom of the will, etc. Kant justly denies to all such conceptions the validity of objective knowledge; he, in fact, treats them as the deceptive shows of speculative reason, and he dilates on the difficulties, impossibilities, and contradictions which emerge when we take them up and treat them as questions of knowledge.

In his "Critique of Practical Reason," however, Kant endeavours to restore these conceptions again to their proper place; he shows that they are the necessary conclusions which result from consciousness of the existence within the mind of the moral sense;—that *categorical imperative* which imposes a law on the will and actions, and whose dictates are in conformity with the highest law of reason, or, at least, in conformity with the highest reason of the individual. Kant

regards this law as an indirect evidence, not only of a supreme Governor of the world, but also as evidence of the freedom of man's will. His argument is this—"*Thou canst, because thou shouldst.*"

We cannot enter upon the extensive branch which treats of the transcendental conceptions of reason. To follow Kant in this inquiry would only incumber us; neither do such questions fall naturally within our bounds.

We have endeavoured to give an abridgment of that part of Kant's "Critique," which has reference to the subject of man's sense knowledge, and we have employed his language, as translated by Mr. Meiklejohn, so far as we could, endeavouring simply to lessen the difficulty to the reader by selection and retrenchment, and by the introduction of occasional explanatory words. With all this, we fear, the subject as treated may not be one much suited to the general taste.

In reading Kant, a hundred times do we reflect how differently would a French or English author, in possession of the same materials and convictions, have striven to work them up for public approval. Kant, though he had Scottish blood in his veins, and laid out his subject under as many heads as any old Scottish theologian, was essentially a German,—deeply imbued with the love of labour for its own sake, and persuaded that without a due show of operosity and obscurity no metaphysical or other literary work would in his country secure general attention. In his "Critique," Kant has done all that was necessary in this respect; his positions are not only novel and ingenious, they are laden with all the insignia of an oppressive and suffocating profundity. The result was that the production which Dugald Stewart cast aside as incomprehensible, was found so suited to the German mind as to raise it to a fever heat; and the "Critique" became the inspiring source of all subsequent German philosophy.

There cannot be the slightest doubt that Kant possessed extraordinary analytical powers; but it will be generally felt that, in dividing and subdividing, arranging and rearranging,

the elements of thought, he has carried his elaboration too far. He believed the mind to be a unity; but, borne onward by confidence in his analysis, he has represented it more in the light of a complex machine, whose parts and movements perform entirely different sorts of work. He represents the mind as evolving certain mysterious phenomena, but, at the same time, as quite unintelligent of the external objects which are prompting its action; and not only unintelligent of them, but misconceiving and misconstruing them. The world is thus represented by Kant as a mere deception, or, as he expresses it, *a schein.*

Locke set the example of explaining the faculties of the human mind. Reid, and his successors in the Scottish school, endeavoured to show in what respects Locke had failed in obtaining a sufficiently profound insight into the nature of perception and of thought. With rare sagacity, and with equal simplicity and elegance, this school advanced our knowledge of the thinking principle, and rescued it from the debasement of a sensational philosophy, by showing the mysterious spiritual character of its powers. Kant came in after Reid and Stewart, and with his patient laboriousness and his power of abstract thinking, he did much to enlarge our knowledge of the complexity of thought and of the laws of the thinking principle; and for this we owe him a large debt of gratitude. He might, however, have done much more towards establishing a sound philosophy, had he not chosen recklessly to cast aside his belief in the veracity of those sense impressions which our rational nature teaches us to accept, and preferred to build an unsubstantial physical structure upon a foundation of fanciful idealism. By doing so he has involved his philosophising countrymen, and many in our own more matter-of-fact land, in the prosecution of painful and impalpable abstractions, which, if they serve any purpose, must either lead us entirely to distrust the value of transcendental analyses, or else must lead us to a painful distrust in the teaching of those senses which nature has bestowed upon us.

PART VI.

THE PHILOSOPHY OF THE SENSES.

CHAPTER XXXVI.

INTRODUCTORY REMARKS ON THE SCOTTISH SCHOOL.

REID ON THE DIRECT PERCEPTION OF THE WORLD—HAMILTON ON THIS SUBJECT—HIS VIEWS ON SOLIDITY NULLIFIED BY HIS DENYING OUR CONSCIOUSNESS OF POWER — DISTINCTION BETWEEN SENSATION AND PERCEPTION—OF WHAT IS THE MIND CONSCIOUS?—ARNAULD'S VIEWS—DIFFICULTIES—DISTINCTION BETWEEN OUR PERCEPTION OF THE PRIMARY AND THE SECONDARY PROPERTIES OF BODIES — OUR KNOWLEDGE OF LOCALITY AND OF LOCAL CORPOREAL AFFECTIONS ACQUIRED THROUGH EXPERIENCE.

HAVING in Part II. described the physical movements which affect the organs of sense; and having in Part V. given a sketch of such theories, opinions, and arguments, as might help us to see the difficulties experienced by different minds when led to view the subject under different aspects, the reader may now think himself competent to take a somewhat commanding survey, and form some views of his own touching the great questions which have so long occupied the philosophic mind regarding this extraordinary reality, the world, and regarding the nature and extent of our knowledge of it. In the treatment which the subject has received, the reader will, doubtless, have observed many things which are the reverse of satisfactory. For instance, during the earlier days of Grecian philosophising there was little else on one side than speculation, and on the other than attempts to cut down all theory and all belief by an ingenious use of metaphysical difficulties.

Until hereditary speculations were set aside, and a sounder method was proposed by Descartes, we observe very little of that patient and careful examination into the nature of the knowledge acquired through the senses which could lead to

any satisfactory results. Locke and Hume were the first who, in our country, in different ways and with very different objects in view, undertook a methodical examination of this subject.

Our Scottish writers, who followed, diligently pursued the same inquiry. Reid especially did much to confute philosophical positions which he considered to be false, and to establish a philosophy of truth and common sense by an examination of the faculties of the human mind. He exhibited the mind, as well as the outer world, as being governed by great laws impressed on them by the hand of the Creator. He gave a summary of some of those first principles or elements of thought, the authority of which the mind, from its inherent nature, is compelled to accept. In opposition to Berkeley and Hume he strongly urged that we have a direct, real consciousness of the outer world.

He did not, like Berkeley, allow any theory regarding the essential nature of the mind to throw discredit on the facts of consciousness. He confined himself strictly to an examination of the mind's powers and operations, stoutly maintaining at the same time its incompetence to handle successfully such questions as regard the essential nature either of mind or matter. Reid's cautiousness, indeed, went the length of timidity. This fault originated with him, as it has with many more of our leading authors, from the fear of any irreverent treatment of questions which were supposed to be allied with religious truth. From this circumstance we observe in Reid and Stewart's treatment of perception rather a dogmatic theological statement of the case under the aspect in which they regarded it and other natural phenomena, than any attempt to infuse new light by independent thought and investigation; and thus, notwithstanding the service which they did to philosophy in many respects, and especially by their analysis of the laws of the mind, they left the subject of perception in much greater confusion than it stood in the days of Descartes.

Sir William Hamilton, after pointing out several of the more glaring inconsistencies of Reid and Stewart, joins with them in their great leading conclusion, and strongly and dogmatically asserts the doctrine of a direct perception of the external world. Hamilton, however, had entered the lists,[1] not so much in the temper of a philosopher prepared to investigate and discriminate, as of a champion resolved vigorously to do battle for a cause, and to overwhelm and annihilate Arnauld, Brown, and every adversary who might decline subscription to his peculiar views of philosophical orthodoxy.

Many years later we find Hamilton still holding to the same doctrine of a direct perception of external nature. "Let us try," says he in his college lectures, "whether it be impossible, not to explain, for this would be ridiculous to dream of attempting, but to render intelligible the possibility of an immediate perception of external objects without postulating aught that can be fairly refused.

"Now, in the first place, there is no good ground to suppose that the mind is situated solely in the brain, or exclusively in any one part of the body; on the contrary, the supposition that it is really present wherever we are conscious that it acts,—in a word, the peripatetic aphorism, the soul is all in the whole, and all in every part,—is more philosophical, and consequently more probable, than any other opinion. Admitting the spirituality of mind, all we know of the relation of soul to body, is that the former is connected with the latter in a way of which we are wholly ignorant; and that it holds relations different both in degree and kind with different parts of the organism. We have no right, however, to say that it is limited to any one part of the organism; for even if we admit that the nervous system is the part to which it is proximately united, still the nervous system is itself universally ramified throughout the body; and we have no more right to deny that the mind feels at the finger-points, as consciousness assures us, than to assert that it thinks exclusively in

[1] See Discussions of Philosophy, *Edinburgh Review*, 1829.

the brain. The sum of our knowledge of the connection of mind and body is therefore this, that the united modifications are dependent on certain corporeal conditions; but of the nature of these conditions we know nothing. For example, we know by experience that the mind perceives only through certain organs of sense, and that through these different organs it proceeds in a different manner. But whether the senses be instruments, whether they be media, or whether they be only partial outlets to the mind incarcerated in the body, on all this we can only theorise and conjecture. *We have no reason whatever to believe contrary to the testimony of consciousness that there is an action or affection of the bodily sense previous to the mental perception; or that the mind only perceives in the head in consequence of the impression on the organ.* On the other hand, we have no reason whatever to doubt the report of consciousness *that we actually perceive at the external point of sensation*, and that we perceive the material reality.

"But what is meant by perceiving the material reality?

"In the first place, it does not mean that we perceive the material reality absolutely and in itself, that is, out of relation to our organs and faculties; on the contrary, the total and real object of perception is the external object under relation to our sense and faculty of cognition. But though thus relative to us, the object is still no representation, no modification of the Ego. It is the non-Ego—the non-Ego modified and relative, it may be, but still the non-Ego. Suppose that the *total* object of consciousness in perception is = 12; and suppose the external reality contributes 6, the material sense 3, and the mind 3, this may enable you to form some rude conception of the nature of the object of perception." ("Lectures," vol. ii. pp. 127–129.)

Hamilton attempts here, in much more simple language than is his wont, to explain his notions of perception. But this simplicity is only apparent; the whole passage, when examined, will be found singularly unfortunate and mislead-

ing. In the first place, it is unfortunate that, after premising that he would not postulate *aught that could fairly be refused*, the first thing he does is to postulate what nearly all the world denied; it being all but universally held, at the time he wrote, by men of science as well as by the public, that the mind acts in the brain, and not at the outer organs of sense—an opinion which has since been confirmed by experiments.

In the second place, when he comes to explain what he means by a direct perception, he errs still further; he says, "it does not mean that we perceive the material reality absolutely and in itself; *it is the non-Ego—modified and relative, it may be, but still the non-Ego*—the external object contributing, say, 6, the organ of sense 3, and the mind 3."

We may well inquire what properties of the non-Ego are here referred to as being so modified? No one knew better than Hamilton that colour, sound, taste, and smell were purely subjective sensations, which have no resemblance whatever to the external causes which produce them. These, therefore, must be set out of view. We also set aside the solidity or impenetrability, the weight and the tenacity, and all the resisting properties of bodies; for, as Hamilton well explains, these are discovered by the exercise of our animal activities, and not properly by the senses. There remain, then, the other real properties of bodies to which we can refer, viz. their forms and movements. Now, surely Hamilton, in the passage quoted, does not mean that the form and motion of external bodies as perceived *are modified*. If so, we would ask in what respect are they so modified? Is the cube which is perceived not a cube? the oval not an oval? the chair not a chair? The passage has evidently been written with a carelessness and want of thought unworthy of its illustrious author, and it gives us a misleading conception of what perception is.

Hamilton's ultimate and more careful exposition of his views is contained in some of the notes appended to his valuable edition of Reid's works. In note D he says: "All

perception is a *sensitive cognition*, it therefore apprehends the existence of no object out of its organism, or not in immediate correlation to its organism. Thus a perception of the primary qualities does not originally and in itself reveal to us the existence and qualitative existence of aught beyond the organism apprehended by us as extended, figured, divided, etc.

"The primary qualities of things external to our organism, *i.e.* their extension and solidity, we do not perceive, *i.e. immediately know*; these we only learn to infer from the affections which we come to find that they determine in our organism; affections which, yielding us a perception of organic extension, we at length discover by observation and induction to imply a corresponding extension in the extra-organic agents.

"The existence of the extra-organic world is apppre-hended, not in perception of the primary qualities, but in a perception of the quasi-primary phases of the secundo-primary, that is, in the consciousness that our locomotive energy is resisted, and not resisted by aught in the organism itself; for in the consciousness of being thus resisted is involved as a correlative, the consciousness of a resisting something external to our organism. Both are therefore conjunctly apprehended." (Note D, appended to Reid's Works, pp. 879, 881, 882.)

This passage indicates that Hamilton had at length taken the trouble of giving the subject a more careful examination. His statement, saving the mysteriously technical language employed, seems to us unobjectionable.

Vision presents to the mind the extended forms of objects, but gives us no notion of their solidity. The nerves of touch, as threads from all parts of the body, are collected in the brain, and in this expanded organ there are represented by nerve impulses the various sentient parts of the body; when an object, therefore, comes in contact with an extended part of the body, or with two separate parts simultaneously, we thereby become conscious of organic extension through touch. By vision and touch together, and the perception of

our locomotion, the fullest data are laid before the mind for ascertaining the fact that our locomotive progress is impeded by contact with extended objects.

An important element of knowledge is, however, still awanting; the main property of physical bodies is their solidity or resisting power, and this property Hamilton, although he talks of *impeded locomotive energy*, yet passes over rather slightly. The fact is, in a separate part (see Lecture 39), if we rightly understand the passage, he seems expressly to deny that we have any consciousness of physical power. If this is his position, it is evidently one which is fatal to his argument that we are conscious of the solid or resisting properties of matter. But let us leave this all-important point for discussion in an after chapter.

In consistence with Hamilton's ultimate opinions, and with general belief, we are therefore led to view the body as susceptible to external impulse, but as being in itself entirely *unconscious* and incapable of *sensations*; we are also compelled, in consistence with modern discovery, to admit that the body is not animated, *i.e.* pervaded by the mind, but that the percipient principle is localised in the brain. The statement of details regarding the nature of sensation and perception will, in this case, stand thus:—

We shall find, first, that *sensations* are solely in the mind, and it is very necessary to keep this cardinal truth steadily in view, for it is ever ready at the important moment to slip out of the memory. The habit of stamping our sensations on the outer objects, or upon the insensible organism, is so inveterate with us that we are constantly misled by it.

Secondly, we shall find that when we direct our attention to the sensation, be it colour, touch, sound, pain, or any other sensation, as a something caused by a physical action existing in the bodily organs, we correctly assign it a *physiological cause;* but we in common parlance, and from the influence of habit, moulded by a law of our nature, incorrectly and inconsistently call it a bodily *sensation*. All who are capable

of correct thought will be ready, however, to admit that this expression is a misnomer, seeing that all sensation is now known to be localised in the brain, and to be a mental and not a corporeal affection.

Thirdly, we shall find that when we yield to the practical bias of our nature, and fix the attention on the object, or extra-organic cause of the sensation, we call this operation of the mind a perception of the external object or cause; thus we say, we see the trees, and we hear the pianoforte, and we feel the table, and smell the rose, and taste the food.

Perception of the extra-organic world is thus, evidently, in no respect a direct perception of external objects. The impulse in every instance is transmitted from the external organ of sense to the brain, where it is perceived, or where it affects the mind with the specific sensation required; and in vision and hearing the perception is even more indirect, for the impulses are carried from the distant object through intervening media, and thus, with regard to these two senses, the perception is in a double sense mediate, *i.e.* in each of them the property of the object affects the mind only after a transmission through two successive media.

But if perception is correctly described as *direction of the attention to the extra-organic cause of the sensation, and the holding it to be the object*, it may be asked, of what are we truly conscious during this mental act? There can be little doubt on this point. We are conscious of the sensations produced in the mind by the impulses on the brain. As Hamilton has, however, disputed this point, we shall immediately give it our consideration, but not to interrupt the sketch we are giving of the steps which the mind takes in perception, we shall assume that the direct object of our consciousness is the sensation given to us. Sensation is that mysterious phenomenon which is evoked in the mind by brain action, and which is kept present to the mind all the time that we are exerting that higher scrutiny which we call perception. It is evident that it is this passive mental affection, and this alone,

which we are directly conscious of in perception. But to proceed.

In vision we are conscious, in the second place, of the mind being actively occupied with the thing believed *to exist* and *to be* the cause of our sensations, *i.e.* to be the *cause* of the phenomena of figure, colour, and movement, which stand immediately present to the mind. In the act of perception, then, we may be very sedulously occupied with the consideration of every detail of the phenomena given us in sensation —its qualities, its colours, its forms, its motions, the relative position of its parts, for all these are held before the mind in the visual sensations; and as regards these sensations, we repeat, the mind is passive, and possesses no control, so as in any manner either to alter or reject them.

Such being, then, the nature of the sensations given to the mind, let us give some further consideration to the nature of the mental action employed in perception. It is this: the subjective sensations of which we have been speaking, when presented to the mind, at once excite its active energies. The mind fixes its attention on them, forms a conception of them as existing external things, and, as it were, it projects them outwards from the mind where they are, and regards them for the time not as mental phenomena, but as realities existing in the fields, the trees, the houses which are before us.

Perception has been considered by Plato, and by Kant and many others, as an act whereby the mind forms conceptions, and embodies into a unity, or object existing in time and space, the multiform units of which the object consists. We entirely approve of this definition of our sense conceptions. A thousand elements are combined in the act of perceiving and conceiving, and the philosopher in investigating these has a fine opportunity of exhibiting the powers and activities of the human mind. But restricting ourselves at present to one of the leading rudimentary elements, perception is essentially an act of the mind, in which it regards the mental phenomenon or sensation as an external object. The two

following questions formerly referred to, therefore, again come before us for solution :—

First, is the mind directly conscious of the outward objects ? Assuredly no ; even Hamilton gives up this point.

Second, is the mind conscious of those affections, actions, or movements in the cerebral organ which produce sensation, for if it is so, then it is, as Hamilton insists, conscious of what is external to itself, namely, of the bodily affection, and thus of a part and portion of the external world ?

Anthony Arnauld, doctor of the Sorbonne, a friend of Pascal, and the opponent of Malebranche, in opposition to this view, held with most of the disciples of Descartes, that perception in its passive aspect is only a *modification or affection of the sentient principle*, induced by physical impulses.

We consider that the settling of a distinction of this kind lies entirely beyond our reach, and it certainly is not necessary that a realistic philosophy should insist on a settlement. If the wax is conscious of the impression made by an object external to itself, it is sufficient proof of the existence of the seal which impresses it. This may be regarded as a clumsy illustration. It is so, but all we can say in the experience of our felt incompetence, is that personally we incline to concur with those philosophers who regard perception as a condition of the mind in which it is conscious of its own specific states or sensations.

Hamilton, however, held this difference in theoretical belief to constitute an all-important distinction between those who maintain a direct perception of the organic affection, and who, he maintains, are therefore alone entitled to be called realists, and those others whom he calls cosmothetic theorists, because they cannot accept his position, and who, therefore, he incorrectly alleges, only infer the world to exist, but deny that they have a direct perception of it. Now, it is easy for any one to make himself a realist of this kind, by saying that he believes the mind to perceive the cerebral movements ; but it is very evident that, unless he can prove

the point, the mere possession of belief is of little value to the world or to philosophy. Let us see, then, how the matter stands. In vision, let us suppose a sheet of paper placed before the eyes, the impression of this is cast on the retina of each eye, and the two impulses are united into one in the sensory, and, this done, immediately the mind becomes aware of a white square phenomenon. The exact nature of the cerebral action it is not necessary here to inquire into, we shall call it merely nerve action. What is present to the mind is a square white phenomenon. If we hold that we perceive the nerve action expanded in the sensory, then we may properly say we perceive a physical phenomenon. But if we hold that the mind is merely acted on by the nerve action, and that the mental affection thereby produced is what we are conscious of, we more properly call it a sensation. Which of the two views is correct? This is, as we have said, a point which lies beyond our reach; but, at the same time, if we consider that the mind possesses no immediate intellectual apprehension of the nature, or even of the existence of the nerve action, but is conscious only of figured colour, we shall naturally incline to decide that the mind is *acted on*, and perceives only its *own affections* or *sensations*. Nor does this appear to us to be practically much inferior in value, as a proof of externality, to a direct perception of nerve action; for, as we have said, to be mentally affected so and so by a cause external to the mind, is practically equivalent to perceiving the external cause or object, especially when by our other senses and by our locomotive energies we have the means of confirmation in every particular and detail.

This, however, it would seem, does not satisfy Professors Hamilton and Mansel, because they insist that in no act of consciousness can the *mental act* be separate from the object of which it is conscious. This is an indubitable position; but the question remains—in perception, which is the object? Is it the mental affection or the cerebral movements? For us it is sufficient that we know that the mind does not call up

visual phenomenon, and that therefore the white square must be held to be caused by an external object corresponding in form, especially as we can obtain constant confirmation of this by touch, and the movement of our arms and fingers over it.

Let us, in conclusion, bring two other points before the reader regarding the secondary qualities of matter. These are usually described and distinguished as being only in the mind. But we call the reader to observe that this description is equally applicable to all our sensations. Our sensations of every kind, so far as regards their qualities, are only subjective affections. Both the secondary and the primary properties of bodies are given us by a direct action on our organs of sense, and which thus evolve sensations: the difference between the one class of properties and the other is that the primary properties present us with forms and motions, which we can study as external physical realities. The sensations of the secondary properties of bodies, such as sound, smell, taste, heat, and cold, on the contrary, are caused by the impact of invisibly and impalpably small particles, which excite an expanded portion of the sensory, yet as the expanded affection never changes in form so as to represent known external forms or objects, we regard these secondary properties chiefly in their subjective relations, and do not regard them as external objects. We merely know by touch and vision that they are caused by external objects.

Thus we are brought again to the old question of Plato, Locke, Reid, and others: Does the external world *resemble* our *sensations?* Our answer is different because it is more specific than theirs. Our sensations, as regards their *qualities*, in nothing resemble the external world. They are mental affections which a little reflection will convince us we cannot even conceive to exist external to the percipient mind; such are sound, colour, heat, smell, taste, touch, and all others. But in as far as any of our sensations embody forms, or motions, or anything which may be known or considered as an external

object to occupy the intelligence, to this extent the sensations resemble the external reality. It is important, however, to observe that the sensations produced by what are thus called the secondary properties of bodies, though they reveal to us neither motion nor length, breadth nor thickness, nor anything which we can study as an external reality; yet, as they are very various and distinguishable, they are of paramount importance to us. They serve their appointed purposes by being signs of a vast variety of important external qualities, properties, and conditions; and by their pleasantness, or by their beauty, they at the same time either fill up life with enjoyment, and prompt mental and bodily energy; or, on the other hand, by their painful or disagreeable character they warn us of what is detrimental.

Other and very important questions may be asked; namely, How do we know by our corporeal sensations the objective causes of the sensations which have reference to the primary properties of bodies, and the parts of the body which are affected? Our reply is: In the brain are assembled the nerve fibres from nearly all parts of the body; the body is thus fairly represented in this central organ. This may in part explain the mind's apprehension of spacial sensation, and in some measure (though in touch more vaguely than in vision) of form and position also.

The sensations of touch, moreover, coming from every external part of the body, have differences in their character, which depend on the different limbs which are affected, as well as on differences in the exciting causes, *e.g.* the hot and cold, the sharp and blunt, the rough and smooth. These act differently on the nerves of general sense. A gentle, steady touch excites one sensation, a succession of rapid, light touches causes another sensation, viz. that of tickling. A hard pressure produces pain, and so forth. The nature of the external excitant, the length the impulse has to travel, the nature of the bony or fleshy media it passes from, or through peculiarities in the nerves themselves, and difference

in the part of the encephalon which they enter, all these serve to give distinctive characters to our different bodily sensations of touch; and habit and experience teach us confidently to assign a locality to each different sensation, so that we at length, as it were, not only know what part of the body is affected, but from knowing this, we also imagine that we feel the pain in the part affected. Every one conversant with young children must have observed how imperfect is their knowledge of the whereabouts of any bodily injury; a pain to them is not an evil in any one part of the body, but the mental Ego is distressed, and the whole organism is by this action in the nervous centre thrown into muscular contortions.

We have said that the habit we acquire by experience, of assigning a locality to each bodily affection, becomes very soon so constant and so prompt that we come to imagine that *we feel* corporeal sensations as if they existed in the part affected, and not where they are, in the mind, and localised in the head. This is just another of those singular instances of how invariably nature makes everything work, not for theoretical, but for practical ends. It is the same in the exercise of all the senses. Thus, when we are occupied looking at an outward object, the mind is entirely led away from the visual sensations, as subjective states, to the external object suggested by them; and it is by the operation of this law that we acquire the habit, which at a very early period of life becomes inveterate, of stamping the mental sensation upon the part of the body acted on, and the part affected, though itself insensible, thus secures our constant care and attention.

CHAPTER XXXVII.

SECONDARY PROPERTIES OF PHYSICAL BODIES.

THEY ARE PERCEIVED AS MERE MENTAL AFFECTIONS—THE QUALITY, AS DISTINGUISHED FROM THE FORMS, OF OUR SENSATIONS—CONFUSION FROM NOT OBSERVING THIS DISTINCTION—REID DENIES THE EFFICACY OF PHYSICAL AGENCY—HOW FAR OUR SENSATIONS ARE SIGNIFICANT, AND HOW FAR ARBITRARY AND MEANINGLESS.

IN vision there is, as it were, mapped and presented to the mind in the sensorium a true representation, though on a different scale, of the forms, motions, and relative sizes of external objects as they exist on the retina of the eye. We have demonstrated this to be the case in chapter xviii. by experimental observations made in connection with the phenomena of single and double vision, and we solicit the attention of the philosophical public to the data by which we establish this fact. We have there shown that two entirely different phenomena in vision, which have long been considered inexplicable, may be accounted for by assuming the contiguity, within a ganglion at the base of the brain, of the nerve fibrils, proceeding from the corresponding parts of the two eyes, which ganglion thus becomes the sensorium in visual sensation.

This representation of the external world, transferred in all its details from the retinæ to the sensorium by nerve impulses, may physiologically be described as a flow of nerve force to that particular part of the cerebral mass. And it is evident that the nature of the action thus produced must be exceedingly delicate and highly complex, depending as it does on the minute distinctions in the vibrations which produce the various colour effects observed in visual phenomena.

So much regarding our perception of the forms of objects. Then we have, in the preceding chapter, stated that we are rendered conscious of the solid resisting properties of bodies, not directly by the senses, but by the consciousness we have of being possessors of physical power, and the knowledge that this power in us is resisted by contact with external objects, each obstruction requiring a certain measure of force on our part to overcome it. In chapter i. we have endeavoured to show that the mind is conscious of this effort, and is itself the prime director and agent in all voluntary motion and physical action, and we have also endeavoured to show how the mind acquires this consciousness of physical power.

We shall now direct attention to what are called the secondary properties of physical bodies. These are colour, sound, taste, smell, heat, and cold, and, we shall add to the list, touch proper. It is supposed by the uneducated, and even by a large portion of the educated but uninquiring portion of mankind, that these are properties of matter. A little reflection will convince any one that such is not the case. Our usual misapprehension on the subject arises very evidently from the circumstance that we are constantly in the habit of connecting the cause of sensations with the sensations themselves, and conceiving the one to agree with the other. We thus naturally come to believe that there is sound in a piano, colour in a rose, taste and smell in an apple, and cold in a piece of ice. It becomes a form of thought with us and a sentiment, which even in the face of our better knowledge, except when we are purposely philosophising, we naturally retain, and so far thus, in obedience to the rules of our mental constitution, conferred by a beneficent hand, we fill up and adorn external nature with melodies colours, tastes, and odours, which, though excited by external agencies, yet exist as sentiments and sensations only in the mind.

We need not do more than state, what is so well known, that sound is a mental sensation, and that the physical cause

is a motion of the air, and a succession of rapid impulses on the nerve; the physical cause has here no resemblance to the mental result which follows—the motion and force of outward, invisible particles is evidently very different from a note of the piano as perceived by us.

In the same way light and its constituent elements, as we have in its proper place explained, are caused by still more rapid and minute vibrations of an elastic medium, and these vibrations acting on the optic nerves produce, in accordance with the laws of our mental and organic nature, the sensations of light and colour. There is thus evidently neither light nor colour external to the mind. These are purely mental affections, produced by physical means which bear no resemblance to them.

Taste is always accompanied by a sense of touch, and we naturally connect the taste with the food producing it; but it is clear that though sugar affects us with the sensation of sweetness, there is nothing corresponding to this sensation in the crystallized substance, sugar.

Smell is produced by volatile particles emanating from various bodies entering the olfactory apparatus, and exciting the nerves of smell; and as with taste, so with smell, it is a mental affection which in no respect resembles the volatile excitants.

The sensations of heat and cold are felt when cold bodies are brought near, or in contact with, the body, and this sensation marks a particular negative state of the substance, well understood by scientific men, but which is singularly ill fitted to express the sensation it excites in us. All this is well known to every tyro in philosophy.

The sensation of *touch* is commonly divided into touch proper, and the more vague, muscular sensations felt during physical exertion. Touch proper is the sensation experienced when any body, soft, hard, or even aerial, affects the surface of the body with any sensation, the highest sensibility being in the tip of the tongue and at the finger ends. At Reid's

time it seems to have been held that by touch we detected the hardness, solidity, and other resisting properties of bodies. This was evidently scarcely a correct statement of the case. Touch proper merely enables us to declare that the surface of the body has been affected; but it neither informs us by what the affection has been produced, nor whether it has been hard or soft. Let the hand be tied down to the table, with the palm presented upwards, let the eyes at the same time be bandaged, and let an expert person touch the hand lightly with various substances, hot and cold, hard and soft, in succession; if this is skilfully done, the patient operated on will be quite unable to do more than guess what are the properties of the various substances. The sensation of simple touch, except when conjoined with voluntary motion and pressure, gives us no impression of the resisting properties of matter. Touch is a sensation which by itself is not in any high degree a peculiarly instructive one; but when it is combined with well-directed movements and the exercise of the judging faculty we render it extremely serviceable. Thus when we draw the fingers over a surface, by the peculiar quality of the feeling, joined with a perception of the amount of friction, we at once discover, and with great nicety, the texture and the roughness or smoothness of the object. There is, perhaps, no organ of sense whose action is so dependent on the ways in which our intelligence teaches us to use it, as the organ of touch. When an unknown object is put into the hand of a blind man, observe how inquiringly his fingers pass over it, the points of the fingers, and even the edge of the nails, scrutinising its every chink and joining, in order that he may know its form and structure, and may surmise its use.

We are here led naturally to inquire into a very important and curious part of the subject, and one which carries us at once, if thoughtfully considered, into the mysteries of our nature, and brings us more, perhaps, than any other part of the subject to a conviction of the spiritual nature of the mind, and of that Being whom we regard as the author of our

existence. It is that part of the subject which has reference to the nature and offices of our sensations, and chiefly what we shall designate their qualities: that which Kant, who delighted in inverting the usual signification of words, called their *matter*, but which we think may be much better described by the word which we have employed. We shall therefore speak of the *quality of sensations*, as distinct from the form and space aspect, in which the sensations of vision and touch present themselves.

The subject of our sensations is one which has greatly occupied the attention of the Scottish school, but not very profitably. We cannot find that Reid, Stewart, or Hamilton make any important use of the distinction between the *form* and the quality of our sensations. When Reid takes up the subject of the primary and secondary properties of matter, in spite of many just remarks we soon discover that the primary object he has in view is to overthrow the lingering doctrine regarding *the perception of ideas*, which, from the days of Plato to his own time, seemed to him, in one form or another, to have infested philosophy, and afforded a footing for idealism. Reid, pressed by this necessity on the one hand, and by a dread of materialism on the other, and influenced at the same time by a Scottish prejudice, not unobservable in our own day, against any attempt to employ human intelligence and science to explain mysteries, was thereby rendered peculiarly unfitted for that candid and deliberate examination of the subject which it required..

Reid, in order to root out every form of this time-honoured doctrine of ideas, took up the position of the unlearned, that we neither perceive ideas nor sensations, but that in every case we perceive the external object by sight, by taste, by hearing, by touch. But how to prove this was the difficulty, for, as we shall see, he accepted without qualification the doctrine that our sensations have no resemblance to the objects which we perceive and believe in. Such being his belief, he might well ask, How can we through these sensations have

a perception of external reality? This was, indeed, a puzzle. Reid cut the knot by holding that we do not perceive by sensations, but that Deity gives us a direct and immediate perception of the outward object through each of the senses.

In endeavouring to establish this position, Reid involved the subject of sensation and perception in the utmost confusion. The world, according to his theory of perception, is not a physical system where each element and each part subserves a special purpose, and acts according to the laws which regulate it; on the contrary, the world is regarded as virtually inoperative, and perception is entirely irrespective of physical properties or agencies. Reid says as much as this in several places, and we are compelled to infer it in others.

Hamilton truly remarks on Reid's and Stewart's theory: "This view virtually denies the existence of matter as an efficient cause, making the Deity the only efficient cause in perception; it goes even far to frustrate the whole doctrine of the two philosophers in regard to perception as a doctrine of intuition. For if God has bestowed on us the faculty of visionally perceiving the external object, there is no need to suppose the necessity of an immediate intervention of the Deity to make that act effectual." ("Lectures on Metaphysics," vol. ii. pp. 125, 128.)

This practice of explaining perception by the interposition of Deity was an effectual bar to all rational inquiry, and served as an apology for any amount of carelessness or one-sidedness in our scrutiny. Previous explanations of perception had been unsatisfactory, and some of them had been profane; the more inscrutable, therefore, Reid represented the subject to be, the less he thought it was likely to be again tampered with.

But in saying this we are stepping beyond the point we mean to examine, viz. the qualities of our different sensations, and a distinction peculiar to the senses of touch and vision,

in respect that these two, along with the sensations peculiar to them, embody also the element of form which none of the others do ; while the one set of sensations, then, are mere arbitrary signs, these two, touch and vision, besides being signs, are something more, they present to us the patterns of external reality. The distinctions in our sensations depend, so far as we know, on four separate causes : first, there is our mental ; second, our physiological constitution ; then there is the nature of the external agency, or action, which affects us ; and, lastly, there is the nature and structure of the different organs of sense. With reference to this last, we at least know that, without the suitable organs, we could not have the various and specific sensations of which each organ is the inlet and channel. To express our meaning more comprehensively, there are in nature so many agencies specifically different in their modes of action, and we have organs framed specially to receive impressions from these. Thus light only acts on the eyes, sonorous vibrations on the ear, aroma on the organ of smell, sapid bodies on the organ of taste. We may, therefore, declare generally that through each distinct organ of sense, an agency in nature acts on us in a specific way, and thus *may be said to be perceived* by us, though we do not distinguish the separate molecules, or parts.

Locke very briefly states the broad distinction between the primary and the secondary properties of bodies. He says,—" The qualities that are in bodies rightly considered are of three sorts (Book II. chap. viii.) :—

" First, the bulk, figure, number, situation, and motion or rest of their solid parts ; those are in them whether we perceive them or not. These I call primary qualities.

" Secondly, the power which is in any body, by reason of its insensible primary qualities, to operate after a peculiar manner on any of our senses, and thereby produce in us the different ideas of several colours, sounds, smells, tastes, etc.

" Third, the power that is in a body to make a change in the bulk, figure, texture, and motion of another body. Thus,

the sun has a power to melt wax white, and fire to make lead fluid.

"The first are resemblances; the second are thought to be resemblances, but are not; the third neither are, nor are thought so, but are regarded as powers."

We repeat, then, that all our sensations, however different they may be, agree in this,—

First, they are mere feelings, correctly enough expressed by the word *sensation*.

Second, they are all the result of an action on the different nerves of sense.

Third, a sensation being the perception of a sentient being, in its quality as a sensation possesses no resemblance to the external objects or causes exciting it.

Fourth, our sensations are, therefore, to be regarded, in so far as their quality is concerned, as mere arbitrary and meaningless signs, which by virtue simply of their qualities can convey no knowledge of the nature of external reality; this we concede to Reid. But we must observe that this is but a partial view of our sensations; for—

Fifth, besides feeling, or quality, there is also furnished by certain of our sensations the *forms* of external things; and to this fact, as we have already said, many of our metaphysicians have shut their eyes, being satisfied to repeat simply the old phrase, that sensations in nothing resemble the outward object.

The sensations, though they are not the only and sufficient gateways of knowledge, are yet chief and indispensable elements; without these it is certain we could have no acquaintance whatever, either with the world, with our vital organism, nor, so far as we can see, even with our existence. It is the law of our being that the mind, though it possesses wonderful powers, and is capable of reaching truths which far transcend mere bodily considerations, is destined to commence its growth by conceptions which have reference merely to these sensations and the objects which

excite them. It is first roused into a sense of its existence by impressions made on the physical organism with which it is connected ; nor can we easily conceive how it could become conscious of its existence except through these; for even when it has attained maturity it is only conscious of sensations, ideas, actions, passions, memories, reflections, and never of itself. These, and such as these, constitute all the mind knows of its own being.

Though our sensations are thus the *sine qua non* of our intelligence, it is singular how little we are in the habit of considering their nature or qualities, or inquiring how through them we acquire knowledge. The reason is obvious. Sensations, like all arbitrary signs, serve their purpose; they direct the attention, not to themselves, but to the object which they represent. Just as in reading a book the mind is engrossed with the subject matter therein treated, while the letters and words,—without which we could know nothing of the author's aims,—having served their purpose, drop from the mind and are forgotten, so it is with our sensations. We seldom attempt to abstract them from the objects which they represent, or seek to feel and know them as they are in themselves. It requires some effort to do this. It is much more easy, however, to do so with some of our sensations than with others, and the reason is plain—certain of them have much more connection with the indulgence of the animal wants than with intellectual cravings; and these sensations we are in the habit of enjoying for their own sakes. Thus the sensations of the palate we very easily isolate and examine. We find even in these, however, very little that we can describe; we can merely say that they are pleasant or the reverse, that they are sweet or bitter, salt or acid, etc., which means that the sensations have special characters which vary with changes in the excitants.

The sensation of smell differs from that of taste, though when it is excited by an edible it so strongly suggests the usually accompanying sensations of taste, that they seem to

have an almost inseparable affinity. Let the reader when his eyes are shut apply an odorous body which is not an article of food to his nostrils, and let him confine his attention to the odour as a sensation, without any reference to the object exciting it, and he will be best able to understand what we mean by the quality of the sensation.

A dog, whose knowledge is chiefly derived through odours, probably is as little accustomed to abstract the qualities of the odorous sensations as we are to consider the sensations of touch and colour *per se*. It interprets them very much as we read the columns of the newspapers, and in its morning rambles it picks up intelligence of all the accidents and offences, arrivals, transits, and departures which have occurred in the neighbourhood, doubtless without once consciously isolating the different sensations by means of which it has acquired so much knowledge.

As a general rule we find that the more the sensation is usually connected with an exercise of the intellect, the less are we in the habit of separating the quality of the sensation from the external object with which we connect it.

Thus in vision the mind is occupied generally with the object—its nature, form, position etc., and not with the colour as a sensation. If we dwell on the colour, which we often do, it is to obtain information concerning the conditions of the object, experience having taught us that, with regard to this, colour is a trustworthy index : thus by the colour of the cheek we judge of health ; by the colour of the soil, and of the crops, we judge of their fertility, luxuriance, and maturity. The mind, however, it is evident, is here occupied with the external conditions of objects, and not with the quality of the mental sensations—white, brown, green and yellow. There can be no doubt these colours are sensations, that is to say, mental affections produced by certain invisible impulses on the ocular nerves, but we so constantly connect colour with the solid object which determines the radiation of these impulses into the eye, that we can scarcely reflect on it, or

on its quality, as being a subjective affection. It is always presented to us in some extended form, which becomes the subject of our attention and study, and not, like sound, as a purely subjective sensation. Then, again, its action on the nerves is generally refined and delicate, and we are scarcely conscious of the seat of the affection ; it seems rather to be out of us on the object which occupies our attention than within us. Let us, however, increase the strength of the sensation by gradually throwing stronger light on the object, and we shall find that we thus become sensibly more percipient both of the quality of the sensation and of its organ. The sensation of colour, if we carry the experiment too far, becomes a sensation of uneasiness ; and if we direct the eye to the sun, the sensation of colour is transmuted into one of painful brightness.

We have no difficulty in distinguishing the different sensations of colour, but they have in them no meaning, and therefore we can find no language to describe them in a way by which they may be recognized. So much is this the case that it is impossible to ascertain, as Dr. Reid remarks, whether the sensation which is red or blue to me is the same to my neighbour. We can describe any geometrical figure, and we can tell the laws of a circle, a square, or a triangle ; but colour, sound, taste, smell, touch, the sense of heat and cold, and the muscular sensations, we cannot with all our ingenuity describe intelligibly.

Regarding sound, although so much of our enjoyment and knowledge is derived through it, and through the conventional forms into which we throw it in speech and in music, yet we cannot describe the abstract quality which we call sound as a thing which contains any meaning inherent in it. By discovering that particular sounds are associated with particular events or processes in nature, or that particular meanings have for purposes of utility been put upon certain sounds or combinations of sound, we acquire a large stock of knowledge through its use ; but the meaning is not incorporated

in the sound, any more than the meaning of a telegraphic message is incorporated in the beats of the needle; the connection is purely a conventional one; and the same must be said of touch and of all our other sensations. It must have been solely in the aspect of a pure sensation that Reid regarded touch, forgetting that when associated with voluntary motion touch gives us much more than mere tactual sensations; it gives us, like vision, though less distinctly, a perception of extension and of the forms of external objects in the way we have more than once mentioned.

CHAPTER XXXVIII.

THE PRIMARY PROPERTIES OF PHYSICAL BODIES.

DIFFICULTY FELT BY REID AND STEWART REGARDING POWER, CAUSE AND EFFECT, AND PHYSICAL EFFICIENCY—REID NEGLECTS THE DISTINCTION BETWEEN THE QUALITY OF OUR SENSATIONS AND THE FORMS IN WHICH THEY ARE PRESENTED — HAMILTON ENIGMATICAL — STEWART ENDORSES REID'S VIEWS ON PERCEPTION—HIS MYSTERIOUS EXPLANATION OF PERCEPTION—LOCKE.

NOTHING affords more instruction in a subject of this kind than the practice of examining the difficulties which have beset its progress, and which may have baffled the efforts of its earlier explorers. We, therefore, return to the opinions of Reid and Stewart in order to direct the reader's attention to some of the difficulties which these eminent writers encountered, and we shall point out what appear to us to be the errors which are mixed up in their writings with much sound and valuable instruction. The reader will thus ascertain the light in which the subject of perception was regarded by the two earlier writers of the Scottish school; he will see, also, the corrections of some of their more glaring errors, as proposed by Sir Wm. Hamilton. In making this historical retrospect, the author intends, if not fully in the present chapter, at least before closing the volume, to point out in how imperfect and confused a state the subject has been left, notwithstanding its filtration through so many metaphysical minds.

We shall reserve for a later chapter the statement of our own views, as they have moulded themselves after many years of reflection, both on the physics and the metaphysics of the subject; and we trust we may succeed in rendering the subject somewhat consistent and intelligible.

We shall begin by refering to Reid's "Inquiry into the Human Mind," where he deals with the subject of sensation and how we acquire a perception of external objects.

"The firm cohesion of the parts of a body," says Reid, "is no more like that sensation by which I perceive it to be hard, than the vibration of a sonorous body is like the sound I hear.[1] Here there is a phenomenon of human nature which comes to be resolved. Hardness of bodies is a thing that we conceive as distinctly, and believe as firmly, as anything in nature. We have no ways of coming at this conception and belief but by means of a certain sensation of touch, to which hardness hath not the least similitude, nor can we by any rules of reasoning infer the one from the other. The question, then, is how we come by this conception and belief.

"First, as to the *conception* of hardness. The origin of this idea of hardness, one of the most common and most distinct we have, is not to be found in all our systems of the mind, not even in those which have so copiously endeavoured to deduce all our notions from sensation and reflection.[2]

"But, secondly, suppose we have got the *conception* of hardness, how come we by the *belief* of it? Is it self-evident, from comparing the ideas, that such a sensation could not be felt unless such a quality of bodies existed? Can it be proved by probable or certain arguments? No, it cannot. Have we got this belief, then, by tradition, by education, or by experience? No; it is not got in any of these ways. Shall we then throw off the belief as having no foundation in reason? Alas! it is not in our power, it triumphs over reason, and laughs at all the arguments of a philosopher.

"What shall we say, then, of this conception and of this belief, which are so unaccountable and so intractable. I see nothing left but to conclude that, *by an original principle of*

[1] Cohesion or hardness being one of the primary properties of matter, Reid selects it as affording a good illustration of the difficulties felt.

[2] An allusion to Locke and others of the sensational school.

our constitution, a certain sensation of touch both suggests to the mind the conception of hardness, and creates the belief in it ; or, in other words, that this sensation is *a natural sign of hardness*." (Reid's "Inquiry," chap. v. p. 121).

This is simply saying that the sensation of touch, though having no resemblance to hardness or solidity, yet suggests its existence. We cannot tell why or how, except by *reason of an original principle in our constitution*. This is, of course, no explanation ; it is simply showing the difficulty and leaving it, as not only unexplained, but as if it were entirely inexplicable by any natural cause.

Following out the views thus avowed, Reid continues :—

"What we commonly call natural causes might with true propriety be called *natural signs ;* and what we call *effects*, the *things signified*. The causes have no proper efficiency, or causality, as far as we know, and all we can certainly affirm is that nature hath established a *constant conjunction* of the things called their effects, and hath given to mankind a disposition to observe those connections, to confide in their continuance, and to make use of them for the improvement of our knowledge, and increase of our power."

Here we have the position which had been taken by Berkeley and by Hume regarding cause and effect, indorsed by Reid, the champion of realism. He denies the efficiency of natural causes, and suggests that they may be mere signs; so that there may be possibly no hardness in a table, no tenacity in a piece of iron, no gravity in lead, no energy in light and heat, no use in the stomach, heart, brain, or any of our organs. If this is the case, then there is no use in the world, and we have all been under a delusion when we have admired the apparent adaptation of means to ends, and the wisdom of the Creator in His works. Reid must have been sadly pushed before he ventured so far to adopt Berkeley's views. Is it a confusion of language, or of ideas, which causes so much disagreement on the subject of cause and effect ? Reid and the majority of philosophers

agree in holding that there is a great unseen Being, who created the world and all things. From this point a difference in opinion commences; some philosophers hold that Deity created what is called matter, and somehow endowed it with its properties, so that it became thenceforth an independent agent, and that by virtue of its powers and properties all the operations of the physical creation are conducted. Others hold that the Being who called the world into existence is ever present sustaining the active operations and energies of nature—He being the real and efficient cause, acting according to those laws which we call the physical laws of the world. In this latter view, matter, if it is a real thing, becomes, as Reid represents it, only the *sign* or *occasion*, an inert mass, an idle hanger-on in creation. It is needless here to say that each of these theories is beset with its own peculiar difficulties, and, as we must think, with very serious objections; and this has driven us to propose a new physical theory. Reid evidently held the latter of the theories alluded to, viz. that matter is in itself inert, and that its apparent action is the direct outputting of Divine power.

Assuming this to be Reid's theory, the distinction between the two theories, though it may be important in a metaphysical point of view, yet it seems to us that it should not practically affect the explanation of perception. For under each of these theories of nature the world is represented as governed by the laws of God's appointment, and therefore power and efficiency exist and are exerted in all physical bodies, whether they be naturally inherent in them, or whether they emanate from the Being whose power pervades all nature. If, for instance, we regard this Being as the creator of all things, we must still regard the eyes as the organs which converge light to the retinæ, and the nerves as the organs which carry the impressions to the brain, and these impressions as the agencies which immediately affect the intelligent mind with the sensations which are re-

presentative of the extended objects and the external motions; and it does not practically alter the case whether the various organs, and other agencies, act by virtue of inherent powers of their own, or by virtue of Divine power acting in or through them. When a mason, with a mallet in one hand and a chisel in the other, splinters pieces from a block of stone, we understand perfectly the different steps of the process; we understand the working of the mind of the living agent, and we understand the peculiar action of the different instruments.

Power is as real a thing as matter; nay, much more real, for we are conscious of the one, while we only surmise the existence of the other. In the instance given we know the existence of power, its measure, and its mode of manifestation, in each instrument and in each motion of the operator. God, no doubt, is the source of all the physical powers of nature, but the arm, the mallet, and the chisel, are the means or channels through which the masonic purpose is accomplished, and power is the perceived reality which binds together each succeeding action and effect. Though the power in the instruments be God's, yet it is exerted thus and thus, *i.e.* by localised and physical action.

And we must judge in the same way in tracing the steps which connect external nature with the percipient soul in the act of perception. If we believe Deity to act at every link, this, far from leading us to deny physical efficiency, should rather serve to explain to us how physical bodies are efficient, and it should inspire us with a desire to trace the various physical steps by which in a physical world the Supreme Mind accomplishes the different results. We therefore protest against Reid and Stewart's habit of scouting all attempts to discover the physical steps involved in perception. In doing so they are not only unphilosophical but they are inconsistent with their own theory of nature; for while they theoretically hold that Deity in the world does everything, Reid in the chapter alluded to, and Stewart when he treats of perception, strive to prove that Deity reveals external objects

to us, not in accordance with, but irrespective of, the physical laws which have been instituted. Thus they assert that we receive no information by means of our sensations, and that the properties of bodies and the organs of sense are of no real service. We constantly find ourselves beseeching its great apostle in the name of common sense to inform us how it is possible to believe in the intercourse between mind and matter if we disregard entirely the properties of one of the two factors.

It is evident that in considering the sensations peculiar to vision and touch, Reid has fallen into the trap laid for him by Bishop Berkeley, and has confined his attention strictly to the *quality* of the sensations, and overlooked the fact that these sensations embody in them the forms, figures, and motions of external objects. Had he kept this *physico-mental* fact in view, he would not have considered our perception of extended objects so inexplicable. We now know that appropriate nerve impulses are sent to the cerebral lobe from the organs of sense for the purpose of giving us the special sensational presentations. Reid and Stewart would not for a moment have allowed themselves to be influenced by any such physical explanations, but it was from their obstinate rejection of evidence that their inquiry into the nature of perception was rendered unproductive. It is very evident, as the authors alluded to say, that the mere *quality* of the colour and of the touch sensations can afford us no explanation of how the consciousness of chairs and tables gets into the mind. If, however, the sensations embody figure and extension, the problem becomes easy enough. We see, then, how Reid, in his bewilderment, was led to propound a theory of perception which denies the operation of physical laws.

In vindication of his position he, in the same chapter (chap. v. p. 124), says, "I have sought with great pains, I confess, to find out how this idea of extension can be got by feeling; but I have sought in vain . . . . for the feelings of touch do not more resemble extension than they resemble

justice or courage." Hamilton in a foot-note to this passage remarks, "All the attempts that have subsequently to Reid been made to analyse the notion of space into the experience of sense, have failed equally as those before him."

To this remark we have only to add that metaphysicians must be very slow in making physiological discoveries, even when they stare them in the face. The idea of an extended sensorium presenting to the mind extended impulses from an extended, nerve-pervaded body, one would suppose had not occurred either to Reid or Stewart or Hamilton.

It will assist the reader to see the difficulties felt by Reid, if we present him with one more quotation from this author's Essay on the Intellectual Powers in reference to Vision. (Chap. xiv. p. 301.) "When we say that one being acts upon another, we mean that some power or force is exerted by the agent which produces or has a tendency to produce a change in the thing acted upon. If this is the meaning of the phrase, there appears no reason for asserting that, in perception, either the object acts upon the mind, or the mind upon the object. An object in being perceived does not act at all. I perceive the walls of the room where I sit; but they are perfectly inactive, and, therefore, act not on the mind. To be perceived is what logicians call an external denomination, which implies neither *action nor quality* in the object perceived." It would be difficult to find any passage in print more full of evident error than this one. If there is neither action nor agency, energy nor quality, in external objects, then for what purpose are all the wondrous adaptations which we observe in the ocular apparatus, and in the relations between it and the laws of light? The nature of colour, as dependent on the property of the object radiating it, and the wonders which science reveals to us, are all neglected and disowned in the passage quoted.

Stewart follows Reid in this, and conceives that his predecessor has rendered a great service to philosophy by shutting off all physical considerations while he was treating of the connection of the spiritual principle with the physical world.

"Dr. Reid," says he, "was the first person who had courage to lay aside all the common hypothetical language concerning perception, and to exhibit the difficulty in all its magnitude by a plain statement of the fact. To what, then, it may be asked, does this statement amount? Merely to this, that the mind is so formed that certain impressions produced on our organs of sense by external objects are followed by corresponding sensations; and that these sensations, which have no more resemblance to the qualities of matter than the words of a language have to the things they denote, are followed by a perception of the existence and qualities of the bodies by which the impressions are made; and that, for anything we can prove to the contrary, the connection between the sensation and the perception, as well as that between the impression and the sensation, may be both arbitrary; that it is by no means impossible that our sensations may be merely the occasions on which the correspondent perceptions are excited; and that at any rate the consideration of these sensations, which are attributes of mind, can throw no light on the manner in which we acquire our knowledge of the existence and qualities of body. From this view of the subject it follows that it is the external objects themselves, and not any species or images of these objects, that the mind perceives; and that, *although by the constitution of our nature certain sensations are rendered the constant antecedents of our perceptions, yet it is just as difficult to explain how our perceptions are obtained by their means, as it would be upon the supposition that the mind were all at once inspired by them, without any concomitant sensation whatever*." ("Stewart's Philosophy of the Human Mind," chap. i.)

Further, on the same subject, he says, "As one body produces a change on the state of another by impulse, so it has been supposed that the external object produces perception, which is a change in the state of the mind, first, by some material impression made on the organ of sense; and, secondly, by some material impression communicated from the organ to the mind along the nerves and brain. . . . . 'As to the

manner,' says Locke, 'in which bodies produce ideas in us, it is manifestly by impulse, the only way which we can conceive bodies to operate in.'" ("Stewart's Philosophy," chap. i.)

Locke, in the passage quoted by Stewart, exhibits much more candour and sagacity than the Scottish writer, who was impeded by his materialistic terrors.

Influenced by the danger of speculating on such subjects, one of the chief aims of the Scottish school was to restrict inquiry strictly to psychology, and within this sphere its efforts have adorned mental philosophy with an amount of sound and ingenious thought, conveyed in clear and elegant diction, which will secure for their writings a permanent place in the literature of our country.

On the subject of perception, however, their Scottish caution, and prejudice against free inquiry, has led them to obscure rather than to illuminate the subject. Locke, by the free exercise of practical common sense, notwithstanding his failure in opening up to us the faculties of the human mind so fully as might have been desired, has, in the remark on perception just quoted, struck upon a true and evident explanation. We have only to substitute the word sensation for Locke's ambiguous word *idea*, in the passage quoted, and his surmise becomes, so far as it goes, substantially unobjectionable.

It will be our duty in a later chapter to show that this view of a nerve impulse producing sensation, if properly examined, involves nothing tending in any measure to encourage materialism, as our Scottish philosophers supposed.

CHAPTER XXXIX.

PHILOSOPHY SEEKS AN EXHAUSTIVE THEORY OF THE WORLD.

PHILOSOPHY is the search for truth. It is not satisfied with the mere outward show of things—it seeks to know their meaning in the highest sense. Now, in the three preceding chapters, in seeking to explain the facts of perception, we have stated those results which scientific investigations and the application of common intelligence lead us to; and the subject viewed in this way is in no small measure curious, showing as it does a strange mysteriousness in the working of the human mind in its intercourse with external nature. But this glance should only serve to sharpen the desire to have the matter further examined, so as if possible to satisfy reason and the inquiring instincts of our nature.

There exists, no doubt, an order of mind which rests satisfied with visible and outward facts. Other minds, however, have cravings which prompt the possessors to value facts such as the senses furnish, chiefly because of their being signs or indications of a something more important lying beneath; without this reference they look upon material things much as a horse may be supposed to view a picture of hay and oats, as lacking all nourishing and strength-giving qualities.

Unless, then, our intelligence can in some way connect observed phenomena with a *sufficient cause*, we possess no key by which to ascertain their nature, purposes, or modes of acting, and philosophy has failed in her quest.

This sentiment has pervaded philosophy through all its course, and that such is the case is evinced by the persistent efforts which in all ages have been made to separate truth from

error in sense-knowledge, prompted by the conviction that there lay under it a mystery which had not yet been reached, and that this species of knowledge, unless properly interpreted, was philosophically speaking little better than illusion, because it did not reveal the ultimate meaning and cause of what was by the senses presented to us.

The connection of mind with matter afforded another and equally interesting problem. How a spiritual nature could act on matter, and how matter could act on mind? This has, especially since the days of Descartes, been constantly agitated by philosophers. The connection between these two incommensurables has been felt to be one which not only could not be explained, but which seemed openly to defy all attempts of this kind. Of a similar character was the question, What connection can an infinite spirit have with matter such as we conceive it—and how does such an entity come to exist; how can a spiritual being call into existence a thing entirely different from his own essence? These difficulties cannot fail to arise so soon as we compel the subject to pass under our review.

Anaxagoras is said to have been the first who by power of thought reached the great idea of inert matter being ruled by an intelligent principle, and thus becoming a WORLD. But it was the soul of Plato which first threw out mystic imaginings regarding the nature of this lower world, and ventured to regard it as but the shadow of a higher and more Divine system. To him matter was the unintelligible which concealed the real, while at the same time it faintly imaged it forth, and philosophy, accordingly, was with him the inspiration which enabled *heaven-born souls* to pierce through the cloud and to declare the real meaning of what the senses revealed. To know was with Plato, not as it is with some of us, to make a catalogue of visible facts and phenomena—to know was to comprehend the *eternal idea of things* as construed by reason.

Philosophy has constantly found itself compelled to

connect, or to identify, nature with an Infinite Spiritual Being. From this necessity arose the dark but sublime pantheism of Spinosa; the beautiful and ingenious idealism of Berkeley; the incomprehensible spiritual monads of Leibnitz, and his theory of a pre-established harmony between mind and body, which represented their relationship as only one of association, and denied the possibility of true reciprocal action between them.

Descartes, by the sharp line which he drew between mind and matter, and which was esteemed his crowning merit, threw difficulties into the problem of perception, which up to the present time seem not to be removed, but which apparently still stand out as insurmountable.

Geulinx was, it would seem, the person who attempted to force the question to a decision. He did so, as we have seen, by denying the existence of any action between the material and the spiritual. He held the outward object to be but the occasion for Deity revealing to the mind the existence of the material object. We have seen also how closely Reid and Stewart homologated this view. The same difficulty led Father Malebranche to his theory of the soul of man *beholding all things in God—à cause que Dieu veut que ce qui est en lui, qui les représente, nous soit découvert.*

Kant also laboured to swell the list of matter doubters, and he added himself to the number. He nominally accepted the doctrine of an external world; but by denying our possession of any proof of its space and time qualities, he denied not only the existence of matter, but also of the world in any intelligible shape, and led the way to the rampant German idealism which philosophy has adopted.

These things we deplore, but there must exist a cause by which to account for the many extravagant theories which persons, supposed to be the wisest, have been driven to propound, nor is the explanation far to seek. The doctrine of the creation of a substance possessing the wonderful properties ascribed to matter is so fraught, as we shall see, with

difficulties and contradictions, that thinking men, in seeking to avoid them, are driven into positions often equally absurd and untenable.

Newton it would seem modestly explained to Locke and the Earl of Pembroke his views of how we might dispense with matter. And Hamilton, reflecting on the same subject, states that the human mind cannot form the conception of a new entity. He therefore leads us to infer that he did not believe in matter. "As we cannot conceive," says he, "new existence to commence, therefore all that now is seen to arise under a new appearance, had previously an existence under a prior form. When God is said to create out of nothing, we construe this to thought by supposing that he evokes existence out of himself, and we think the *cause* to contain all that is contained in the effect—the effect to contain nothing which is not contained in the cause." ("Lectures," vol. ii. pp. 377, 378.)

Faraday also, who devoted his life to the study of nature, and who, by the ardent application of a peculiarly sagacious and also metaphysical mind, pierced deeper into her secrets than probably any man of this century, was, in conducting certain chemical and electrical experiments, led to the conclusion that matter did not exist. (See *Phil. Magazine*, 1844.)

When we consider what the ideas of the generality of mankind are regarding matter, we at once see some of the difficulties. Matter is conceived, by most men, to be a self-dependent, indestructible thing, composed of invisibly small atoms, occupying space, and having various constant properties, such as solidity, inertia, cohesion, gravity, and certain chemical attracting and repelling properties; and in consistency with this theory, it is held, that through the operation of these properties all the processes of inorganic nature are conducted. Some men even hold, as we have seen, that it is by the operation of these ordinary properties of matter that the infinite variety of vegetable and animal organisms are produced, along with their peculiar habits,

instincts, and reasoning powers. According to this theory, the presence of Divine Power in the world is practically, if not theoretically, denied, for if matter possesses those powers, then what need is there, as we have formerly said, for the interference of Deity, except it be at long intervals, when it may be perhaps judged necessary to interrupt the smooth current of material law, and recast an entirely new order of things.

By our following out this theory, God is practically denied all participation either in the greater or the smaller events and movements of the physical universe. This, though repugnant to the natural feelings of a large portion of mankind, and in many ways objectionable is, we admit, not necessarily an atheistical theory, for at least it may be held subject to the following explanation. We may believe that matter has been created by Deity, and that He has endowed it with the properties necessary for conducting the operations of a physical world, from the simple movements of gravity up to the as yet unexplained phenomena of animal and vegetable function. Many difficulties will, however, arise immediately that we endeavour to reconcile this supposition to our reason, and we doubt whether any man, capable of calm thought, has ever long rested satisfied with such a theory of delegated power. Not to mention metaphysical difficulties, it is sufficient here to say that the belief in the existence of a Being of infinite power and intelligence, is inconsistent with the belief that He stands aloof from the world which He has created. The belief of an infinite power rather tends to enwrap everything within His folds, and to represent Him as the one and only agent—everywhere present—everywhere acting; and as a mental act, it certainly will be found much easier for any man to form the conception even of *the one substance of Spinosa, doing everything*, than of an *infinite power doing nothing;* and yet the majority of mankind, even in this enlightened age, indolently accept as true the theory that comes first to hand, and thus hold practically by this most intractable of all doctrines. They see a stone fall down, and they believe that

this arises from a power called gravity or weight, inherent in the stone as a stone, which draws it to the earth.

While this is truly and practically the belief of nine hundred out of the thousand of educated persons, they, like Roman Catholics in the question of transubstantiation in the Eucharist, hold a double faith. As men of observation, they believe that the stone possesses inherent and independent powers, but as religious men, they believe that the stone's properties are conferred on it and sustained in it by God. This is, we have said, holding two contradictory faiths, and therefore this profession cannot be regarded as a belief at all, for no man can possibly believe two contradictory facts; namely, first, that the stone acts, secondly, that it is not the stone but Deity who acts. When, therefore, the matter is seriously inquired into, so long as we believe in the existence of the entity matter, one or other of the two beliefs must be chosen: we must either believe that the stone is the efficient cause of solidity, tenacity, gravity, and various chemical and physical energies, or we must hold Deity to be the efficient cause. We cannot hold both the theories at the same time. The great majority of thinking men have accordingly, like Reid and Stewart, in spite of the exceedingly awkward position in which it puts the subject, denied all efficiency or use in matter, and held it to be *only present*, but doing no work, —Deity being the real agent, and matter being the mere occasion of His putting forth His power. How has all this perplexity arisen, which has compelled philosophers either practically to make matter their God, or, on the other hand, to dissociate efficient power entirely from it? The cause is very evident: they have unwarrantably assumed the existence of the entity matter, a thing whose existence they have all along admitted could not be proved; and, rather than part with it, they have preferred to make dry sticks of the world, by keeping the figment, matter, before them, even though discharged and emptied of the element of power which alone is of value.

Instead of this folly, let us view the world in the light in which science reveals it to us. It is admitted now on all hands, that all the operations of nature, and all the properties of physical bodies when examined, resolve themselves only into different manifestations of *power*. If we view the world, then, in this light, and hold at the same time that it has been called into existence by a Divine Power, the conclusion follows of necessity, that the world is a manifestation of the power of the Being who has called it into operative existence. The world thus becomes an exhibition of this ever-present, active energy; not *matter and power*, but *power acting in accordance with physical law*, and thus fulfilling the purposes of the Being who has instituted such a system, and who has placed us and other sentient creatures in connection with it.

We have only to judge for ourselves regarding the world as a system of dynamics. Solidity, we repeat again, is the mere resistance to compression. Tenacity is the force by which the parts of bodies are held together. Inertia expresses the amount of force employed in causing bodies to move. Momentum is conversely the force required to stop moving bodies. Gravity is the power which draws masses towards each other. Chemical action is the power which draws atoms together according to their appointed affinities. Heat and light are but peculiar manifestations of mechanical force in rapid motion. In fact, the whole universe, so far as science and observation instruct us, is nothing but power acting in a variety of ways, and it is the province of modern physics to ascertain and tabulate the amount employed in producing each natural phenomenon, and each voluntary animal action. Where then is matter? Science cannot find it. The chemist resolves it into those mysterious ultimate atoms which are only known as centres of force, and which, in their aggregation, constitute the physical bodies whose existence we know by virtue of those various powers which we have now enumerated. We need not go into detail, for if we recognize the atom as a mere centre of force (see

chapter i.), all the laws of science are better explained in consistence with this theory than by any other.

Philosophers, then, if they seek truth, need not in their search go beyond what science teaches them. And they must all see clearly enough that had they kept to this, and made a proper use of that spiritual element of *power* which is alone revealed in nature, they would not only have avoided many foolish theories in past times, but would long ere now have piloted philosophy into a secure and serene haven. For so soon as we avail ourselves of the right key, it is astonishing how a whole legion of errors and difficulties disappear, and how the advantages of truth crowd in upon us. Under such a theory of power, philosophy no longer jars with science, as has hitherto been the case under the ordinary theory of mind and matter; on the contrary, a dynamical theory gladly accepts all the facts of science, and turns them to good account. It regards the world as a Divine system, efficient in all its parts, each agency or organ subserving its special end, and all being measured and proportioned to the work to be performed. Such a theory enhances the dignity of physical science, by giving the world and its belongings an additional significance. It displaces the unsatisfying views of atheistic materialism, and it allows the Christian philosopher to feel himself free for an unprejudiced examination of all the facts, theories, and discoveries of modern times, relieved from the fear of those lowering influences which a too exclusive study of physics is sometimes thought to induce. As we have said, it also very materially simplifies philosophy, and furnishes us, as we shall show in the next chapter, with the means of enunciating a rational and exhaustive theory of perception. And, lastly, by this theory, we can with equal simplicity and intelligence contemplate the curious subject of animal power, or that control which the mind exerts over the bodily organism in voluntary motion, and through it on external nature.

CHAPTER XL

POWER.

THREE QUESTIONS REGARDING POWER—THE MENTAL AND PHYSIOLOGICAL PHENOMENA WHICH ACCOMPANY PHYSICAL EFFORT—OPINIONS OF HUME, REID, BROWN, MILL, HAMILTON, AND FRASER—OUR KNOWLEDGE EXTENDS NOT TO THE ULTIMATE CAUSE OF POWER—THE PERCEPTION OF THE ACTIVE PROPERTIES OF MATTER IS TO US THE PERCEPTION OF POWER—REID AND HAMILTON'S VIEWS ON THIS POINT INCONSISTENT WITH THEIR REALISM—OUR PERCEPTION OF EXTERNAL RESISTANCE MEDIATE, NOT DIRECT—OUR KNOWLEDGE OF CERTAIN PROPERTIES OF MATTER THE RESULT OF ENTIRELY DIFFERENT PHYSIOLOGICAL AND MENTAL PROCESSES—INOPERATIVE MENTAL EFFORT—THE MUSCULAR SENSATIONS.

THERE is nothing man has so strong a conviction of as that he is a real and not a sham agent in the world—that he is, in fact, the depository both of mental and of physical power.

Metaphysicians have, however, raised some questions regarding the grounds of our natural convictions on this point. Our present chapter we therefore mean to devote to the subject of physical power, and especially in connection with certain questions of metaphysical difficulty; such as, Whether or not we are the possessors of power. In what way we become conscious of possessing it. And, lastly, how we bring it into action, or make it operative.

A great deal of seeming learning has been employed in discussing these questions. We consider the subject well worthy of examination. No doubt a great deal has been written in confuting what no one asserts, and in asserting and proving what no one doubts. But, in order to avoid this, we shall endeavour to be as simple and practical as possible. By this course, even if we are drawn into difficulties, the area of the field of dispute will be rendered more definite and narrow.

We shall first lay down the facts which are accepted by all.

When I lift a heavy stone I am conscious of several things; as,—

First. Of an act of will or volition. *I wish at this moment* to lift the stone.

Second. The mere indolent wish to lift the stone does not suffice. I have to bring my body into due relationship with the stone. I have to grasp it with my hands. This being done, I have next to bring both my mind and my body into a peculiar state of action—this I call a physical effort. It may be an easy and pleasant effort, or it may be a difficult, a serious, or even a painful one, this depends on the amount of work to be done, and on my mental and physical ability to do it. If I am in health, and actively disposed, even a great effort may be one which I enjoy.

Third. In this effort I observe several things; namely, first, that the volition, or act of will, is accompanied by, and merged in, a fixed attention and determination, and a continuous effort of my mind, which, for the time, excludes more or less all other objects and considerations.

Again, I observe that the amount of mental effort is proportioned to the work to be accomplished. If the stone is one whose weight will tax my utmost powers, the mind assumes an attitude of solemn anxiety in preparing itself for its part of the work, and the face is found to be a true index of the mental state.

Again, during the whole time that I support the heavy weight the mental action is sustained. If it is interrupted but for a moment the muscular tension relaxes, and the stone falls to the ground.

I note some other physiological accompaniments. I observe that the muscles are contracted till they appear, to use the popular phrase, as hard as whipcord.

I observe, also, that there is a sensation transmitted from the severely taxed muscles, which is called the muscular sensation, and which is evidently produced by the contracted state of these organs acting on the sentient nerves, which

are ramified in them. I also observe that these muscular sensations vary in intensity according to the amount of strain upon the muscle at the time.

I observe still another thing, namely, that there is an increased circulation during this effort, and that the veins gorged with blood stand out, especially in the throat and temples, showing that more blood is being sent to the head and brain.

We have taken the case of an extreme effort being made, because this more palpably demonstrates the different circumstances which accompany the act.

We justly designate an act of this kind an effort. It is a *putting forth of physical power*, and the important question would seem to be, Whence comes this physical power, and how does its action originate? Metaphysicians, however, after careful study of mental phenomena, have raised another question which they make preliminary to this one, viz.: Are we, during such an effort, conscious of exerting physical power?

The reader will, perhaps, be best made aware of the difficulties which metaphysical writers have experienced by our placing before him some extracts from Dr. Thomas Reid's "Essay on the Active Powers." He says, "Power is not an object of any of our external senses, nor even of our consciousness. That it is not seen, nor heard, nor touched, nor smelt, needs no proof. That we are not conscious of it, in the proper sense of the word, will be no less self-evident, if we reflect that consciousness is that power of the mind by which it has an *immediate knowledge of its own operations*. Power is not an operation of the mind, and, therefore, no object of consciousness. Indeed, every operation of the mind is the exertion of some power of the mind; but we are conscious of the operation only—the power lies behind the scene, and though we may justly infer the power from the operation, it must be remembered that inferring is not the province of consciousness, but of reason." (Chap. i.)

We call attention also to the following passage, so provocative of thought, from the same author, and which we may

view as the supplement and illustration of the doctrine announced in the passage just quoted.

"I do not know how my volition produces a certain motion in the nerves; I know not, nay, I am uncertain, whether I be truly and properly the agent in the motion, for I can suppose that whenever I will to move my hand, the Deity, or some other agent, produces the motion of my body. I am like a child turning the handle of a hand-organ—the turning of the handle answers to my volition and effort. The music immediately follows, but how it follows the child knows not. Were two or three ingenious children speculating upon the subject, perhaps one who had seen strange effects of mechanism, might conjecture that the handle, by means of machinery, produced the music. Another, like Malebranche, might conjecture that a musician, concealed in the machine, always played when the handle was turned." (Reid's Works, p. 80.)

Now the case, as here stated and illustrated, may have checked inquiry in Reid's days, but it will not satisfy us now, for physiology has made some progress since Reid's valuable essays were written. It would appear, however, that metaphysicians have, at least as regards this point, not altered their position, and so far as we can learn, it is still held to be an established principle that the mind is not conscious of possessing power. We need not go farther than the writings of Hamilton, J. S. Mill, and Professor Fraser, to establish this. These writers all follow in the wake of Hume, Reid, Stewart, and Brown, in denying that we are conscious of power, either in the mind or in the external world. The subject is so startling and curious that it well deserves examination, and it is important, at least, to understand the meaning of writers so eminent as those referred to.

It appears to us that the whole of Reid's statement, which we have quoted, is liable to challenge. In the first place, it is founded on a transcendental principle, at variance with his philosophy of common sense, and which if carried out would be entirely subversive of his doctrine that we have a

perception of the properties of the physical world. He errs, we think, from want of a just apprehension of the mental and physical phenomena occurring during perception and during voluntary physical effort, and his conclusion is thereby rendered unsound.

It must certainly strike every reader as a singular conclusion for a mental philosopher to arrive at, that the mind is not conscious of its own powers. We naturally start at hearing such a declaration. We know indeed that the heart, one of our most active organs, is constantly propelling blood through the body, and yet that it is entirely unconscious of the work it is performing. But we would naturally conclude that the intelligent principle within us must be conscious of its own voluntary actions; for instance, of the act of thinking, and of the act or operation of regulating the bodily movements, and of dealing with the obstructions met with in the outer world. Dr. Reid, if we understand him, seems to admit that we are conscious of the operation of thinking, but not of the *power of doing it*. He *knows* that man enjoys the benefit of voluntary motion, but he *doubts* whether this motion is in any measure caused by himself, whether in fact he moves, or is merely moved. He knows that we have a *belief* in the existence of *power* to enable us both to think and to walk; but in the passages quoted, he denies that we are *conscious of possessing* this power, and he is unable to account for our acquiring such a belief. Power is, according to Reid and many other writers, a something of which *we cannot be conscious.*

Lest it be possible that we are misconceiving Reid's meaning, and discussing a point different from that to which he refers, let us here explain that we entirely agree with him in holding that we shall, with our present faculties, never understand the nature and essence of the thinking principle so as to be able to declare how or why it should possess the means of exercising either mental or physical power. We shall never, by the use of our present facul-

ties, know what constitutes the mind's efficiency, because everything in this world is known only by its properties, or by what it does, and these are known by us only as they have relation to our powers of knowing; the ultimate essence or nature of things, depending as it does on a cause unseen, lies entirely beyond our mental reach. To adopt Reid's expressive language—*this lies behind the scene.*

This acknowledgment of ignorance of the ultimate nature of things must not, however, be stretched so as to embrace what lies within the range of human experience. If, then, we can attribute to the human mind the possession of any faculties and powers whatever, it seems to us to follow that we must be conscious of the possession of these powers. Power is, in fact, the only thing of which as intelligent beings we are really conscious. Above all, we are distinctly conscious of the active energies of our own minds. Then, as regards *physical concerns*, we do not perceive matter—this is admitted; but assuredly we *are conscious of the active properties, or powers, which physical bodies exhibit*, of impenetrability, weight, momentum, tenacity? What are these but manifestations of the active energies, or powers, or physical properties, as perceived by us. Colour, light, and sound are in like manner the result of energy transmitted through the nerves to the brain. It is ever power, resistance, energy, presenting itself in different ways, that we perceive, and nothing else.

We know that we possess an acting, thinking, willing, designing principle, because we are conscious of all these voluntary mental acts. And, as regards our method of giving physical effect to the designs of the mental principle, we know that we possess bodies organized expressly to fulfil the desires of the mind in its intercourse with the world, and that the mind's seat is in the brain. The question is, Does the mind act, or does it not act? Is it an agent, or is it merely there, doing nothing but willing and wishing?

Reid, as we have seen in a previous chapter, inclines to

think that in the act of perception matter does nothing. We are still more surprised to find, that an author who is treating of the *active powers of the mind*, should assert either that this spiritual principle has no active power, and does nothing in the operation of voluntary motion, or, that it is a matter doubtful, or incapable of being proved, whether or not its volitions are merely *occasions*, on the occurring of which the unseen cause, like the supposed musician concealed in the barrel-organ, produces the motion of the limbs.

While we believe in the transcendent fact of the existence of a Great Being, the creator of all things, we believe as firmly that nothing exists in vain, and therefore that the physical world exhibits real energies—every link in creation, every substance, every element, performing the functions assigned it. And the mind of man and of other creatures we view as endowed with intelligence and power. Man, assuredly, we regard as a real, acting, intelligent, and responsible being, and not as a mere puppet, acting only as he is acted on, as Reid's theory would permit us to believe.

According to the theory which we hold, and which, we need not say, is the one generally accepted by mankind, the mind possesses two very different functions or powers; first, the power to think, and, secondly, the power to act on the body through the medium of the brain and nervous system, and thus to produce voluntary motion. The mind is the prime agent in effecting the discharge of the cerebral influence, which causes muscular contraction; and the muscular contraction is the result of the mental effort. This act of the mind is assuredly an exercise of its powers. It is a voluntary mental act, and therefore we are conscious of it; and at the same time it may be called an act of physical power, inasmuch as the mind thereby acts on the brain, and causes it to exert its peculiar functions in the production of the nerve current which moves the limbs.

Reid says, "Power is not an operation of the mind, and so we cannot be conscious of it." We say, on the contrary, *the*

mind is a self-conscious power, and the act performed by the mind, in voluntary motion, is an act of power, and the mind, which is the actor, is necessarily conscious of its action. *It is conscious that it is exerting an effort, and that that effort is effectual* in producing the physical movement. Why should we speak of resistance, unless we are conscious of it, and that our power is opposing it, and counteracting and overcoming it. When we press the hand against the wall, or when we raise up a heavy stone, we are conscious of resistance. Impenetrability and weight are prominent characteristics of physical bodies, and if we are conscious of these we are conscious of physical power, and we are conscious also whether it be great, moderate, or small in amount. Physical power and physical resistance are convertible terms. If it is wrong to speak of *power*, it is equally wrong to speak of *resistance* or *solidity*. And if we deny our consciousness of the latter, which Reid will scarcely do, we must deny our consciousness of the former.

When we approach a stone and put our physical frame into a proper connection with it, we are in a position for the mind exerting its power, and thereby acting on the complex organism with which it is connected, and through it lifting the stone. The mind puts forth an effort, suitable in kind and degree, to accomplish the work, and the work is accomplished. And if the eyes were bandaged, the mind could tell, within a few ounces or a few pounds, the amount of force or resistance experienced in accomplishing the operation.

This faculty, possessed by the mind, of calculating and allotting the amount and distribution of its physical power, is one of its most wonderful accomplishments. Observe a skilful musician performing a rapid passage—not only does the mind direct the movement of the fingers, but it also distributes the exact amount of force which is due to each note. Were it not for this exquisite command of power, the performance would prove a very flat and discordant affair.

This position assumed by Reid, Hamilton, and others, of

denying our consciousness of power, is entirely subversive of the principles of realism which they theoretically espouse, for it leads to this contradiction: they assert, as realists, that we perceive the table or the stone by sight and touch; but they deny that we perceive the solidity, impenetrability, weight, and other physical properties which distinguish these objects. For it is evident that if we are not conscious of exerting pressure on an object, we can never discover that it is a solid physical substance.

What attention metaphysicians may now-a-days pay to physiological discoveries we know not, but they must know pretty well that the barrel organ, alluded to by Reid, has been partially laid open, and the connection of the handle, the barrel, and the bellows, has been established, and we can now with some intelligence connect the act of the organ-grinder with the musical result which follows, and can prove that the harmony is obtained, not by any supernatural agency, but in strict accordance with the laws of nature.

It is very important that we have a distinct understanding of what is meant when we say that we are conscious of the resistance of external bodies. In examining this subject, let it be kept in mind that all perception and all consciousness is in the mind, and that what we call a perception of *external resistance,* is not a *direct perception* of the resistance offered by the external object; what we are *directly* conscious of is the amount of mental effort which the mind exerts. The amount of external resistance is therefore estimated, as we have previously explained, by the amount of mental effort which we are conscious of exerting in overcoming the resistance offered by the external object, whether that be much or little. And this is a perfectly reliable criterion; for it is an axiom of reason, as well as a fact in physics, that action and reaction are equal.

It is interesting to observe here, as elsewhere, the practical character of the mind, and how its attention is ever directed outward to the end and object it has in view, rather than

inwards to its own actings. An outward effect is what it desires to accomplish: say, for instance, it is the removing a heap of stones of different size and weight; it is towards the successful accomplishment of this object that the attention is principally directed, and the nature and amount of mental action is regulated by what is judged to be necessary from moment to moment, as we proceed with the work. It is from this all-important habit that we naturally project, so to speak, the mental effort of which we have been speaking, outwards, as if it were felt localized in the resisting object, and so we falsely come to imagine that we are directly conscious of the outward resistance offered, while we are only conscious of our own mental effort, which is confined to the region of the brain.

The reader will now understand how, while perception of the *forms, relative sizes, motions, and positions* of objects is acquired by the *sensations* excited, by means of the nerves of sight and touch, our knowledge of the *active energies of nature—solidity, inertia, weight, momentum, and cohesion or tenacity*, in fact, all that distinguishes physical bodies from mere floating and impalpable films, is acquired, not strictly by the senses, but by the conscious exercise of the active powers of the mind, and the correlated corporeal powers; in other words, by the mind and animal powers being brought into immediate conflict with the energies of external nature.

Before concluding this chapter, let us make another remark in reference to the nature of our command of physical power. Even on the first feeling of uneasiness experienced by an infant, its mind will be conscious of an effort to escape from what gives it pain, and the body will, by an effort, jointly reflex and consensual, be moved spasmodically, *i.e.* without any well-directed motion. Now, though the infant will be conscious of what may be called the mental struggle, it will not be conscious of the specific effect thereby produced on its limbs. This knowledge it acquires only by degrees; this seems undeniable. The mind has no consciousness of its

organ, the brain; nor is it conscious that a certain movement of a certain limb will be the result of a certain mental effort. Our direct and immediate knowledge, then, is confined to the knowledge of the mental effort, and of its amount; and the wonderful management which we ultimately acquire over the limbs, comes by our gradually discovering the particular effort which is proper to produce the particular movement.

Reid and Hamilton concur in denying our consciousness of physical power. Reid expresses himself thus: We have very early, from our constitution, a conviction or belief of some degree of active power in ourselves. This belief, however, is not consciousness, for we may be deceived in it; but the testimony of consciousness can never deceive. Thus a man who is struck with a palsy in the night, commonly knows not that he has lost the power of speech till he attempts to speak, he knows not whether he can move his hands and arms till he makes the trial, and if without making the trial he consults his consciousness ever so attentively, it will give him no information whether he has lost these powers or still retains them.

Hamilton, in his remarks on the argument of M. Maine De Brian, who defines the mental effort as an efficient act and a productive energy, says: "This reasoning, in so far as regards the mere empirical fact of our consciousness of causality in the relation of our will as moving and of our limbs as moved, is refuted by the consideration, that between the overt fact of corporeal movement, of which we are cognisant, and the internal act of mental determination, of which we are also cognisant, there intervenes a numerous series of intermediate agencies of which we have no knowledge; and consequently that we can have no consciousness of any causal connection between the extreme links of the chain. A person struck with paralysis is conscious of no inability in his limb to fulfil the determination of his will." ("Lectures on Metaphysics," vol. ii. p. 391.)

Reid's doctrine is to this extent just. We admit that we

have no *à priori* knowledge that a certain act of mental volition will produce a certain movement of the limbs; but if we are conscious, not only of the volition, but of the sustained mental effort which accompanies it in real work, and are conscious that these are followed by corresponding bodily movements and physical work, we have full proof, internal and external, that we are *de facto* exerting power.

Hamilton's statement regarding our unconsciousness of the physical links employed in voluntary action is true, but we are at a loss to discover its value. It might as well be said we have no brain because we are not directly conscious of it. We can prove that we have a brain, and we can prove the connection between this organ and the external limbs by anatomical science, and by physiological experiment; and, *exceptio firmat regulam*, when the connection between the brain and the limbs is severed by disease, or by the knife, this, far from affording proof that the mind has lost its proper power, or its consciousness of power, only proves that it has lost one of its external tools, without which it cannot act efficiently in a particular direction.

Reid and Hamilton's argument is founded on the fact, that when the nerves are diseased, we may put forth an act of will, but it is followed by no physical result. They state this as a proof that we are not conscious of efficient mental power during healthy physical action. We hold the argument to be unsound and worthless. As well might they argue that when an able-bodied sailor gives the first pull to a rope, intending to hoist a sail, but finds that the rope is cut, therefore *he* possesses no strength and no consciousness of it. What we maintain is, that we are only conscious of any act of power, or of any action whatever, when we are exerting it. We are not conscious of the world, or of any external object, unless, *de facto*, it is present to the mind; neither are we conscious of possessing physical power, except when we are *de facto* exerting it. When we are pulling a rope we are of course then alone conscious of doing so, and of exerting power.

The *act of volition* and the mental effort are acts of power, and they impress us with the conviction that they are such by their very nature; and their specific value is communicated to us by the observed physical results which ensue. In the nature of the mental act itself, and in its result, there are thus all the elements which we can possibly desire, to mark it as an effort of physico-mental power. Man has never any stronger evidence of any fact than he has of this act of physical power. And the possession of such a power, let us remark, seems a peculiarly appropriate endowment of self-conscious, animated beings, placed in connection with a physical world. Absolute power over nature appertains only to the Being who wills, and it is done; but it is in consistence with the mental and moral nature of man, and with the nature of the humbler animals, that they should have a subordinate control over the world conferred on them. The possession of this power distinguishes them from insensible matter, and approaches them to that Being whose essence is power.

We believe that in the case of the cut rope, and the disappointed muscular action, the mind actually performs the first step of the physical process; it acts on the brain, which shoots a nervous current indiscriminately through the frame, instead of causing a continuous flow through the nerves distributed to the arms and legs and loins, as would have been the case had the connection between the brain, the arms, and the external resisting object been entire. In the same way when we sleep, or when we suffer from paralysis, the mind may do its part, and put forth an act of power on the brain; and the brain may perform its part, but the connecting link is lost, and the external movement does not follow.

In sleep we sometimes dream we are endeavouring to make tremendous efforts, and this painful mental struggle is sometimes kept up for a considerable time. When we awake, in what state do we find ourselves? The head is hot and aching, the result of violent but ineffectual action, and the

whole frame is more exhausted than if we had been engaged in heavy work. Now we wish the reader to observe, that in such cases, though we are conscious of the desire to exert our limbs, in running, or in struggling with an adversary, yet we are never conscious of exerting physical power, our volitions, on the contrary, are all felt to be empty and ineffectual, simply because they are unaccompanied by the consciousness of resistance, and the usual muscular sensations.

But, after so much writing on the subject, it is very natural for our opponents to ask the question, What is power? This question we only answer by putting to them some other questions, such as these, What is mind, and what is matter? what are time and space? and what is thought? To no such questions can any satisfactory answer be given. We cannot define ultimate principles or ideas, nor can we know anything of the ultimate nature of Being, or of the ultimate causes of things.

It is, as we have said, through the consciousness of our own power, that we discover that power also exists in the things around us in the world. And it is from the consciousness of our own powers, and of the energies of our minds, that we are enabled to apprehend, or infer, that the energies of the world are due to that Great Mind in whom we believe, and whose wisdom shines out in all worldly arrangements.

In conclusion, let us remark that it has been very frequently supposed, and indeed taught, that we acquire our knowledge of the resisting properties of bodies by the muscular sensations felt during muscular action. It will be evident to any one who takes the trouble to reflect, that this is a mistake. These sensations, by themselves, contain nothing that could give us this knowledge. Like all those sensations which convey no impression of external form, they are purely subjective and arbitrary, and contain nothing for the intellect, except it be the indication of their whereabouts. Being found, however, to accompany voluntary muscular move-

ment, and their intensity being ever found to be in proportion to the amount of mental effort, and the amount of work done, we, from this experience, naturally fall into the habit of confounding the sensations with the mental effort, and regard them not merely as exponents, but as direct representations of external resistance. Their function in animal movements is evidently to assist the mind to estimate and apportion its action when it conducts physical work, and without them our movements would display neither the boldness nor the precision which by their guidance we are enabled to exert.

CHAPTER XLI.

ATOMIC BODIES—FREE, AN-ATOMIC, OR TRANSMISSIBLE POWER.

PERCEPTIVE KNOWLEDGE ACQUIRED IN THREE DIFFERENT WAYS—DISTINCTION BETWEEN ATOMIC BODIES AND FREE TRANSMISSIBLE POWER—THE TRANSMISSION OF FORCE—THE THEORY OF FORCE A PROOF OF AN IMMATERIAL BUT EFFICIENT AGENT IN NATURE—THE CONCLUSIONS TO WHICH THIS LEADS—PHILOSOPHICAL STATEMENT OF THE NATURE OF PERCEPTION AS A CONNECTION OF THE MIND WITH THE SUSTAINER OF NATURE'S ENERGIES—ADDITIONAL EXAMPLES OF FREE PHYSICAL FORCE—ITS APPARENT VELOCITY OF TRANSIT—WHAT THIS MEANS—EXTERNAL POWER KNOWN ONLY BY ITS EFFECTS — ITS LAWS — ITS COURSE.

FROM the preceding chapters the reader will have observed —First, that we have an *intuition*, or direct perception, of the *forms* and movements of external bodies presented in the sensorium. Second, that the sensations excited by the secondary properties of bodies possess no inherent significance, *i.e.* we have to seek for the meaning of these sensations, and to discover it gradually by experience ; and, lastly, that our knowledge of the real, substantial properties of bodies is acquired, not properly by the senses, but by finding our mental and animal liberty obstructed by external forces. Our knowledge of the primary qualities of bodies thus rests, not on passive sensations, as Berkeley endeavoured to prove, but on our consciousness of mental and physical power.

In chapter i. we have described solid, fluid, and gaseous bodies as consisting of atoms. Such bodies we shall in the present chapter call atomic bodies, because they are composed of atoms. The atoms are not inert. They have various pro-

perties by means of which they influence other atomic bodies external to themselves, and affect us in the ways which chemical science and our daily experience teach us.

We now wish to direct the reader's attention to the subject of physical power, as it displays itself in ways directly in contrast with the laws which regulate atomic bodies. We may note some of the points of contrast. Atomic bodies occupy space, and their atoms act within very limited circles. Atomic bodies also, as we know, may be moved, but they are impenetrable, *i.e.* one body cannot pass through the substance of another atomic body, except by the displacement of its parts.

The physical power of which we are now to speak possesses nothing of an atomic character. It passes into solid bodies and through them, and emerges from them unimpaired. It acts in a vast variety of ways, and on its action nearly all the phenomena of nature are immediately dependent. It is thus a great and all-important agent in the physical world. We are averse to make use of terms not yet sanctioned by science, but while we shall only bring forward well-known physical facts, we shall, because we present the subject in a somewhat new light, for distinction's sake, call power, when acting in the way we mean to describe, *free, an-atomic, or transmissible* power. One more word, however, first, regarding atomic bodies.

When we describe bodies as composed of atomic centres of force, a difficulty is sometimes felt in conceiving such bodies to possess inertia or ponderosity. The objectors to a dynamic theory seem to regard atomic bodies of this kind as something as empty and useless as soap bubbles, instead of which every substance of this kind is composed of millions of atoms, each one of which, as we have explained in chapter i., possesses all the primary properties of physical bodies. The difficulty with such objectors arises from not keeping this in mind, and possibly from not perfectly realizing the nature of *inertia*. We may use this opportunity, therefore, of pointing out the meaning of inertia, and at the same time

of explaining one of the most important laws of free an-atomic force.

Let us suppose two bodies suspended by long cords, one of them a piece of iron weighing one pound, and the other a mass of the same metal weighing one ton. We know that neither of these bodies will move until force is applied to it; and the same must be said of each of the individual atoms, of which these bodies are composed. Not one of them will move without the application of some force. They are all endowed with the principle of inertia, or fixity, and each atom requires an amount of force, however small, to make it move. If, then, I apply a slight force to the one-pound weight, I make it oscillate or swing forward, and if I apply the same amount of force to the ton weight, although it possesses more than two thousand times the number of atoms, it will also be affected by the slight force I apply, and it will swing forward as the light body did. The force given it has, however, been distributed among more than two thousand times the number of atoms, and as they each take an equal share we cannot expect the movement to be equally swift as that impressed on the smaller body. Observe, however, this important point—there is *exactly the same amount of movement and momentum* in the ton weight as in the one-pound weight, though it is widely distributed. Inertia, then, means that without force no movement can be originated either in small or in large bodies, but that even the smallest force applied, will make as *much* movement in the largest mass as in the smallest, and this is the law whether as regards supposed material or supposed dynamical atoms and bodies. So much regarding inertia.

Let us now pay some attention to the meaning of the word *force* which we have employed in our explanation. The force which we applied to swing the suspended bodies was what we call free or transmissible force. It originated in my mind, which acted on the brain, and by means of the nerves it was transmitted to the muscles of my arm, and

from the arm it passed into the suspended bodies, which it set in motion.

Suppose that, instead of experimenting on suspended bodies, we had rolled a billiard ball along the table, the force which originated in me, would here again be transferred to the ball, and would carry it forward. Suppose now that the ball, when rolling forward, encountered a second ivory ball, of its own size, in a state of rest, it would at once transfer its whole force to this second ball, and the first ball would immediately cease to move,[1] while the second ball would start off instantly with a similar velocity, because carried on by the force it had received from the first ball. The force which originated in me may thus be transmitted through a succession of balls, passing from one to the other; and, if there were no obstruction, and the balls were perfectly elastic, the force which I impressed might be transmitted unimpaired through an infinite succession of balls. This circumstance, to those who reflect on it, must appear a very wonderful and mysterious phenomenon. One thing at least seems clear, namely, that it is the *force* which causes the *motion*, and not the *motion* which causes the *force*. Again, it is equally plain that this force, which we have called *free transmissible* force, is not a material substance. What has been transmitted from me to the first ball, and from that ball to another, is *force, an immaterial, but an efficient influence.* We ask, is it not evident that the distinction between physics and metaphysics disappears when we try to account for phenomena such as this? The truth is, it will be found that the moment we begin to examine almost any physical fact, it becomes a metaphysical problem, and it is wise in us at times to contemplate things such as this which transcend our ordinary matter-of-fact habits of observation and thought, in order that we may thereby become

[1] This would be strictly the case, were it not for a rotatory motion acquired by the ball hit by the cue, which causes it to advance at a certain rate after it has imparted all its direct onward impulse to the ball it hits.

thoroughly aware of the fact that the phenomena of our world, one and all of them, rest upon causes which are not discoverable by the eye of sense, and, if at all, only by the eye of reason.

And here let us call the reader's attention to this practical fact, that the experiment with the billiard balls is useful, as affording us a very simple but complete explanation of the transmission of sonorous vibrations through the air, and of luminous vibrations through the ethereal medium. The stroke, for instance, given to a drum by the drum-stick, *is an act of physical force.* This force the elastic parchment communicates to the molecules of air next it, and these like the ivory balls move forward, and transmit their force to their next neighbours, and these again to others adjacent, and so on the force travels, from molecule to molecule, till it enters the ear, and affects the auditory nerve and the brain, where it is perceived by the mind as a sonorous sensation.

Have we not here, we ask, an explanation, or a theory of the nature and cause of the sensation of sound, such as may satisfy reason, and all reasonable philosophers, such as Reid and Hamilton. Surely on reflecting on such phenomena as we have described of transmitted power, we do wrong to view the sensation as the result of a *material* or *atomic impulse*, and yet this is the light in which most ordinary men have regarded it. Metaphysicians have indeed resisted the physical explanation of perception with all their might, as insufficient to explain the mental result, and have considered it derogatory to the dignity of the mind to be so acted on. It seems to the writer, however, essential to accept the phenomena as the immediate cause of the sensations felt, but it is at the same time our duty to see that the interpretation of the phenomena is a correct one. Now it seems to us much more correct to regard sonorous sensations, and the sensations of sight, not as the result of *material impulses*, as has been generally maintained by physicists, but as the result of that indescribable immaterial principle of force

of which we have been speaking, and which, by means of the rapid vibratory movements, is brought from the object and made to act on the mind. If this is accepted, the difficulties which for so many centuries have beset the subject of the intercourse between mind and external nature are removed, and science and philosophy, on this point, are enabled to advance without any lack of harmony between them. Man is prone to fix his attention on what presents itself to the sight, rather than on that which is unseen, or this view of the matter would ere this have presented itself to him. He has dwelt on the visible movements instead of on the invisible force which he knows to be the efficient element in the vibrations referred to; for he knows well that it is the force which causes the movements, and not the movements which cause the force. The movement of a physical body is only the means by which the force is transmitted from one atom, or from one mass to another, in the way we have explained ; a moving body is strictly a mere vehicle, or carriage, charged with force—the velocity of its movement is indeed an index of the amount of force with which it is charged, but the movement itself has no primary efficiency: *force* is the *cause*, and movement is the *effect;* no one, we think, will seriously deny this position.

The sensations of light and colour, being the result of a vibration, are dependent on precisely the same principle as those of sound ; they are caused by the action on the mind of the immaterial influence or force, transmitted from the sun or other luminous body to the organ of sense, in the way explained in chapter xvii., and sent thence through the nerves to the brain, by means of a physiological action on which we need not here enter.

The connection of the mind with the external world is thus very simply and naturally explained, and we are relieved from the long-felt inconsistency of conceiving matter to act on mind, and mind on matter; and this theory of the mind dealing only with the immaterial element power, seems to us both

strictly scientific and philosophically satisfying. This view of nature may be accepted even by those who adhere to a belief in matter; for if such persons can only be made to see that it is force, and not matter, which is the moving influential agent in the world, the main object we have in view in a dynamical theory of the world is attained, and they will find themselves brought to the conclusion that our sensational perceptions are the result of a direct connection of the mind, not with matter, but with that Being who is the sustainer of all the world's energies.

The views which have been here set forth, it will be remarked, are in one, and that a most important, respect identical with the views of Reid, Stewart, and Berkeley, and, we may add, of Malebranche, inasmuch as all these parties concur in holding that perception is the result of the direct action of the Sovereign Mind on the mind of His creatures. The theory, however, which we have explained possesses, it seems to us, this advantage over theirs: that, in the first place, it accepts the existence of the external world, which Berkeley denies; and, in the second place, while it accords both with Reid and Berkeley in holding the Supreme Being to be the immediate source of all power, and our perceptions to be due to this power, which is His power, it maintains that His power is in this world exerted *in strict conformity with the physical laws of His own institution.*

The world thus falls to be viewed literally as a divinely sustained system, which is operative in all its parts, and not, as Reid and Stewart represent it, a mere outward show, entirely inoperative and inefficient.

The subject of power, or force, has, in recent years, developed itself under the ingenious investigations of scientific men, in ways which, some years ago, could not have been anticipated, and we have been led by it off the ordinary paths of physical research into the field of metaphysics. Power has by metaphysicians been hitherto regarded as an abstraction, a something believed to exist, but unprovable, incomprehensible,

and of which we certainly could have no consciousness. We now begin to discover that this invisible, intangible, immaterial abstraction may be studied and traced by its results, step by step, throughout nature. Our conviction therefore is, that when once metaphysicians have condescended to apply their minds to the subject of physical power, an immediate and most important expansion of thought and opinion will be the result; and many questions which have so long vexed philosophy will be rendered not only clear, in so far, at least, as such subjects can be clear to human faculties, but also in the highest degree satisfying and instructive; and philosophers will find that they have allowed themselves to be discomfited by difficulties which, in many instances, give way the moment they acquire the habit of viewing them properly.

It has hitherto been conceived that the only means of escape from the difficulty involved in holding the mind to be conscious of the existence of external nature, was either to regard the mind and the world as alike material, or else while we held the mind to be spiritual, and the world to be material, to conceive that the intercourse between the two is conducted by a third power, namely, by Deity. Perception has thus been represented in the anomalous light of a miraculous interposition of Deity to reveal His own world to man, and the other humbler creatures placed upon its surface. When we clearly recognize that *power is the operative principle in all physical phenomena*, we at once see that this leads to a much less paradoxical theory of perception. The theory of perception, then, evolves itself in these simple consecutive propositions. It is the power of the supreme Being which constitutes and sustains the energies and forces of nature. These physical forces act on man's mind, and man's mind, as a real spiritual agent in voluntary movements, acts on them. The whole of our intercourse with nature is thus, when reduced to strict and philosophical language, literally the connection of mind with mind—the intercourse between the Great Mind and the mind of His creatures; not, however, be it observed, by

means miraculous and irreconcilable with the ordinary laws of nature, as Reid and others represent it, but, expressly by and through the operation of those ordinary laws of which He is the present and sustaining principle.

We know well that a large majority of persons in this country hold theoretically by the doctrine, that by Deity all things exist, and that He is the Great Agent in all earthly operations; yet when the doctrine is expressed in a practical and philosophical form, as we have done, very few regard it otherwise than as a fanciful theory. It may not be amiss then, indeed it would seem necessary, to direct attention to some few more of the very numerous phenomena which present themselves to those who prosecute the department of science which treats of this particular exhibition of force to which we have given the descriptive name of free an-atomic or transmissible force. We have alluded to one most important manifestation of it in the transmission of mechanical force from one elastic moving ball to another, and in the transmission of mechanical force by vibration from the sun to our earth, and a similar transmission of force from molecule to molecule through the air to our ears. We shall now refer to some cases of a seemingly very different character, and we shall see that there is a principle at work in the world which, though it is neither visible nor material, yet discovers itself both in the outer world and in the laboratories of our men of science by its modes of working out a great variety of physical phenomena. Our examples will be such as are the simplest and best known.

When two metal plates, one of zinc and the other of copper, are partially immersed—facing each other, and one or two inches apart—in a vessel of diluted sulphuric acid, the moment we make a connection between the tops of these plates by a copper or iron wire, a rapid chemical action commences between the zinc and the water, one atom of zinc combines with one atom of the oxygen of the water, forming thus an oxide of zinc, which the acid in turn dissolves, forming

a salt of zinc, which falls to the bottom in a crystalline form.

Water being composed of an atom of hydrogen combined with an atom of oxygen, is expressed in chemical language by the letters HO. Now, as the atom of oxygen has united itself to the zinc, what becomes of the hydrogen? We would naturally expect that this, being a gas, would bubble up close to the zinc where it had lost its mate, but this is not the case. The hydrogen is found rising in a dense stream of little air cells all along the surface of the copper plate, whose substance remains intact, while the surface of the zinc is being rapidly dissolved. Now we cannot suppose that the atoms of hydrogen force themselves through the liquid to get to the copper—Sir H. Davy's experiments satisfied him that this was not the case. The only alternative to be accepted, is that suggested by Grotthus, viz. that the atom of hydrogen H set free, immediately attaches itself to the O of the nearest molecule of water, and the H of that molecule so deprived appropriates the O of the next molecule; in fact, if

HO HO HO HO HO HO

represents the original condition of the water before galvanic decomposition commenced, the following will represent its condition now that the zinc has taken the atom of oxygen—

ZO OH OH OH OH OH H

where each molecule of water has given up its O to its neighbour on the positive or zinc side, and has borrowed an O of its neighbour on the negative or copper side, leaving the hydrogen at the end of the line next the copper to find its way to upper air.

When we consider the great *force* which unites oxygen to hydrogen in water, as is proved by the flame which accompanies their union, we may well wonder that such a chain of decompositions and recombinations can be effected so instantaneously and silently among millions of atoms in the liquid. Science has not yet been able to account for such a process; let us, however, mark the steps which have been discovered.

What is called an electric or galvanic current is found to flow from the zinc through the liquid towards the copper; it passes then up the copper plate along the wire, and then down the zinc plate, thus making a complete circuit. This current will continue to flow so long as the zinc and acidulated water remain.

This is a form of free force of a very important kind as we shall see. Whence comes it? This has, as yet, not been well explained. We only see that there is a rapid process of decomposition and recomposition going on; and as millions of atoms of hydrogen are set free, we may conclude that the force which bound them to the atoms of oxygen is set travelling in the direction we have described as free transmissible force. We are more accustomed to obtain force for economic purposes by destroying the combinations existing in coal in the process we call combustion, but the one process is not essentially different from the other.

The current obtained is called galvanic, because Galvani discovered it, and it used to be called a subtle *fluid*, but it is now generally believed to have nothing whatever of a material character: neither weight, tangibility, visibility, nor atomic constitution are discovered as connected with it. It may be asked, then, how do we know of its existence? This, then, is the next subject of our inquiry. In what various ways does it manifest its existence?

First, then, when instead of one zinc and one copper plate we make an arrangement of several joined two and two, and immersed in parallel rows in diluted acid, we may increase the force of the current to almost any extent. If, as a first experiment, the wires connected with the different poles of such a combination are pointed with pieces of charcoal and approached to each other, the force with which this immaterial agent passes through and from point to point, creates so great a disturbance in the ethereal medium by scattering and dashing the atoms of charcoal and air against it, that an intensity of light is evolved which it is impossible for the eyes to endure.

Again, when the current is sent through thin metallic laminæ, the metal is dissipated into a sort of metallic vapour.

When the current is discharged at fine metallic points under water, the water is decomposed into its elements.

When the wire, again, is cased in silk or gutta percha, and is wrapped round a bar of soft iron, it converts the bar into a magnet which may be made to support many hundredweights or tons at once.

When the human body is made a part of the circuit, the power of voluntary motion is overpowered by the irresistible muscular contractions which are induced.

What name must be given to an invisible principle which acts on physical substances in these ways, and which can be made indifferently to produce light, heat, chemical decomposition and combination, mechanical force, and muscular action. The agent which thus conducts the leading operations in nature we have called *free transmissible physical power*.

It might be thought derogatory to physical power, viewed as a purely spiritual principle, and in fact as God's power, that man should manipulate it, and send it through wires. For philosophers to judge so would be a double mistake. In the first place, man and all living creatures are appointed by their labour and intelligence to appropriate and turn to account the forces of nature, and to bend them to their will. Observe, however, in doing so they neither create nor alter nature's forces, they only make arrangements by which nature may work in a particular fashion for their uses. Thus, when physical power is caused to make a circuit through wires which girdle the earth, and to find its way back through the earth to the closet of the manipulator, this is only a somewhat artificial example of what is going on ceaselessly on a great scale throughout nature. Force is constantly on the move through air and through earth, from body to body, from atom to atom, during every physical change.

It is impossible, of course, that any *fluid* or other *atomic substance* should pass with this velocity through substances of

the same kind. We have evidence, however, of the extraordinary velocity with which physical or mechanical *power* may be shifted. When we remember that the impulse from the sun to our earth is transmitted in this way through more than ninety millions of miles in the space of about eight minutes, we cannot doubt of the possibility of the transference of force from atom to atom of a wire at a similar speed. We may when, we think of this, judge of the commotion excited among the atoms of the connecting wires through which such force is passing, by the fact that when the size of the wire is insufficient to pass the current freely, it is instantly rendered red-hot, and its tenacity is destroyed.

It is important for us to make this reflection, that though physical power has of course no material or atomic constitution, yet seeing that it is the agent in all physical phenomena, it is evident that in a physical world it must work according to physical law, and be fixed and invariable in its modes of action else the world would cease to be what it is. In so far as we can see, all changes in inorganic nature are dependent on the action of physical power — gravity, momentum, cohesion, chemical combination, luminous and sonorous vibrations; and the same power effects the changes in vegetable and animal structures, and, to give an instance appropriate to our subject, it produces that nervous current from the external organs to the sensorium, which causes sensation, and the centrifugal nerve currents, which cause muscular contraction.

As physical power is an immaterial agent, it only exhibits its presence by its effects on physical bodies, we are accordingly exceedingly apt to view it as a product springing from them, instead of which, in one sense, physical bodies are but the objects which are moved and moulded by it: power is the potter, they are but the clay.

Man is conscious of possessing a measure of this all-important power; by it he controls his bodily movements, and through them he impresses external nature.

But whence comes power? It is not material; it is not a

thing which we can at all conceive in its essence. As we never see it, but only its effects, we may perhaps be satisfied to regard it simply as a mode of action brought about by a *cause unknown*. But reason tells us that every effect must have an *adequate cause*, or it is no cause at all; therefore when we see power acting for the production of that order and beauty and enjoyment which abound in the world, and especially when we recognize ourselves as beings gifted with so large a share of physical power and intelligence in close connection, and both of them functions of the mind, we feel compelled to conclude that the unseen Cause of nature's phenomena is a being like ourselves, self-conscious and possessing power and intelligence, though in His case these are unmeasured and inexhaustible.

CHAPTER XLII.

ANIMAL POWER.

RECENT ADVANCES IN OUR KNOWLEDGE—THE FUNCTIONS OF THE NERVOUS AND MUSCULAR SYSTEMS—MOTOR NERVE FIBRES—STRIATED MUSCULAR FIBRES—MUSCULAR FIBRILLÆ—THE NATURE OF MUSCULAR CONTRACTION—THE MENTAL PRINCIPLE AS AN AGENT—POWER OBTAINED BY DECOMPOSITION OF ANIMAL TISSUES—THE PHYSICAL FUNCTION OF THE MIND, OF THE BRAIN, OF THE MUSCLES, IN VOLUNTARY MOTION.

BEFORE making any remarks on the subject of animal power—whence it is obtained, and how it is applied for the purposes of active life—we must know something of the histological structure of the nervous and motor apparatus.

The history of physiological discovery shows how slow and uncertain was the growth of our knowledge regarding the minute structure of the nervous and muscular systems, till recent times, when the use of the microscope has so richly rewarded the labours of investigators as to render physiology almost a new science.

Though much has thus been done within the last twenty-five years, an ample field nevertheless still lies open for future exploration. This is especially the case with regard to the knowledge of the brain, the central organ of animal life, and the medium at once of thought, of sensation, and of voluntary action.

The terminations of the nerves of general sensibility, and of some of the nerves of special sense, have not yet been determined; the functions of the different ganglia at the base of the brain, and the nature of the connection between these gangliæ and the cerebral hemispheres, is still to a considerable

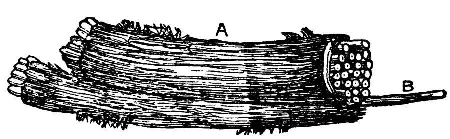
extent more a matter of inference than of knowledge. The reader may easily conceive how formidable must be the obstacles to scientific exploration, when he considers that the brain is an organ whose integrity is not only essential to life, but whose undisturbed action is equally necessary for the natural exercise of the mental faculties.

Experiments on the lower animals, and especially pathological observations, have hitherto been the chief means of instruction, and a good deal of light has been obtained by connecting the circumstances of abnormal vital and mental action with the morbid conditions discovered on *post mortem* examination of the organ; but here, from the complexity of the *brain*, from its acting in two partially independent hemispheres, and from the frequent complications attending disease, this method has not yielded results which have proved perfectly reliable—not unfrequently the results have been puzzling and contradictory. The little we know must therefore be applied with the greater care, in our endeavours to connect together the problems of animal endowment.

We shall now attempt no more than to give as brief an account as possible of the structure and functions of the motor nerves, and of the striated muscular fibre—the two parts of the organism immediately connected with animal motion.

The cerebral and the spinal nerves, which form the media of general and special sensation and of motion, are generally

Fig. 47.

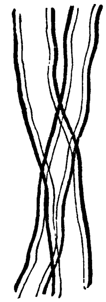


A. A nerve.
B. A fasciculus drawn out.

composed of several bundles, or *fasciculi*, enclosed within a common sheath, each *fasciculus* again generally consisting of many fine nerve fibres.

The nerve fibre consists of a minute tube which is invested with a delicate membranous covering, called the *neurilemma.* Within this is a stronger, more elastic case, called the white substance of Schwann, and within this case, is the centre, or core, called the band of Remak, or the axis-cylinder of the nerve.

Fig. 48.



The core consists of a viscous or semi-fluid, somewhat oleaginous-looking substance, which may be pressed out of the case at the ruptured extremities of the nerve.

The whole white matter forming the central solid parts of the brain lying immediately under the cerebral convolution, is composed chiefly of such nerve tubes compacted closely together.

The investing cases of the nerve fibres suggest to us the electrical insulation of the enclosed nerve axis or core, and it is this core which is supposed to transmit the nerve impulse.

While the brain is the great source whence emanates nerve influence, it is not the sole source; for stimulation or mechanical disintegration of the motor nerves of an excised limb causes spasmodic contraction of the connected muscle. The nerves therefore not only conduct cerebral influence, they may also, when acted on, be made to generate it to a certain extent; and this we might expect, seeing their constitution closely corresponds with that of the brain, of which in fact they are only prolongations.

That there is a steady involuntary nerve influence constantly pervading the muscles we cannot doubt—this is a function of the sympathetic nerves and of their numerous ganglia, and also of the motor nerves. The body is vital in all its parts, and the muscles are thus kept in a tonic condition by virtue of this natural flow of nerve force, else they would not be ready, at a moment's notice from the central organ, to put forth an available action.

There is another circumstance bearing upon and confirm-

ing this fact. Pflugen discovered that when any stimulus was applied to the motor nerve near the muscle, the contractions of the muscle were much more feeble than when the same stimulus acted on a greater length of nerve fibre. This seemed to prove that, irrespective of the brain, the nerve possesses a certain amount of vital energy which may be made available for muscular contraction.

The nerve fibres are largest in the cerebro-spinal nerves, being there about one-thousandth of an inch in diameter. They are smaller in the spinal cord, being sometimes only one-sixteen hundredth of an inch in diameter. And they are smallest in the white matter of the cerebral hemispheres. While in the periphery of the cerebrum and cerebellum they become still finer and are lost among the molecular grey substance of the cerebrum, and the granular layer of the cerebellum. ("Bennett's Physiology.")

So much regarding nerve fibre; next as to muscle. Striated muscular fibre, or contractible tissue, is the immediate organ of voluntary animal motion. A fasciculus, or bundle, of fibres is about 1-350th part of an inch in diameter in man, and it is somewhat finer in females. Each fasciculus is made

Fig. 49.

Ultimate fibrillæ magnified 1200 diameters, showing alternating light and dark spaces, A and B in different foci.

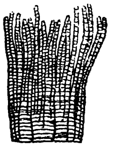
up of numerous much smaller fibrils, or fibrillæ. These are surrounded by a membrane called *sarcolemma.* The fasciculus presents to the eye the appearance of waving transverse *striæ.* When the fibrillæ are separated by a fine needle, and brought into the field of a good microscope, it will be seen that each is made up of alternate light and dark square particles—the light-coloured parts being divided or marked by a very fine dark line.

When the muscle has lost its vitality, and has begun to break up, as it does for instance in the stomach under

digestion, it occasionally breaks across in the direction of the striæ, as in Fig. 50, showing us that the tenacity of muscular fibre is to a large extent due to the vital action, and to the peculiar electrical attraction thence induced between the quadrangular parts. At other times the fibrillæ separate longitudinally, as in Fig. 51.

Fig. 50.

Fig. 51.



The structure of the fibrillæ as exhibited in Fig. 49 is highly interesting, suggesting as it does the alternate plates of the voltaic battery, and also the plates of the electrical apparatus of the *torpedo* and *gymnotus electricus*. But in generating and transmitting nerve-power, the muscular tissue has thereby an attractive and motor action produced between its parts.

When a minute portion of muscular fibre is placed under a powerful microscope and stimulated, the quadrangular dark and light parts are seen to draw closer to each other, and to flatten out, thereby producing contraction or shortening of the fibre; and there is a peculiar satisfaction in connecting the movement which was long inexplicable with the peculiar structure of the fibre now known to exist.

If a connection is made between the outside of a fresh muscle and the inner parts exposed by a transverse section of the muscles, we obtain evidence, by employing the galvanometer, that a faint stream of electricity continues for some time to pass through the muscle, the outside being positive and the inside negative.

If we take a preparation of muscle and nerve, and send an electric shock through the nerve, a muscular contraction is the result, and the muscle returns to its former state in about the fourth part of a second. If a second shock is given before the muscle has had time to relax from the first shock, it causes increased contraction, if a succession of rapid light taps is applied to a nerve, the muscle is thrown into a state of permanent contraction or tetanus.

It is said that a quiescent muscle gives an alkaline reaction, but when the muscle is tetanized, the reaction becomes acid. This would indicate that contraction is at the expense of the chemical integrity of the nerve, and that either the stimulus decomposes the muscle, and produces the contraction, or that the contraction produces the decomposition.

The only other remark we have to make is, that though the galvanometer indicates the continuance of a faint electrical current through a piece of fresh muscle, as above mentioned, this current immediately ceases when the muscle is, by mechanical means, stimulated to contraction, a result which would seem to indicate that the whole nervous and muscular stimulus is utilized in producing the muscular contraction.

Following this information regarding the structure and functions of the nerves and muscles, we complete the subject by some reflections on the two remaining factors, namely, the brain and the mind. It is by means of these that, in all the higher developments of animal life, the functions of voluntary motion are performed.

We adopt the theory of mind being an existence separate from brain action. This theory satisfies reason better than any other. They who profess to believe that the brain thinks, cannot explain to themselves how an organ composed of insensible parts should, by virtue of the mere arrangement of these parts, acquire functions which they believe to be incompatible with any properties of inorganic matter. They cannot see how any arranging of the insensible atoms should produce intelligence, imagination, will, anger, reverence, faith, hope, and charity. It is on this account that we feel justified in retaining the popular theory, and postulating the existence of an acting and thinking principle, different in essence and in function from matter, and also distinct from the organ, even though we should conceive that organ to be formed, not of matter, but of dynamical atoms.

Some physiologists hold that we have nothing to do with such questions, because we can produce no ocular proof on

one side or the other. And they are right, if man is to believe only in what he sees; but man fortunately cannot be brought to disregard the promptings of the higher principles of his mental constitution, simply because its conclusions lie beyond the microscopic field. But do we not see proof everywhere of a spiritual principle at work in the world? Is there not evidence of a formative principle which, out of the albuminous materials of the animal ovum and the vegetable cell evolve the eagle, the lion, the reptile, the man, the oak, the innumerable floral organisms whose symmetry and beauty delight the eye? Is there not a spiritual principle in nature which guides the movements of atoms and of worlds? And does not the same mysterious power which binds the planets to the sun exhibit itself in all the phenomena of chemical affinity; each atom acting on its neighbour external to its substance, obedient to an influence which is never seen. The man who does not discover evidence of the working of spiritual and intelligent power must, as it seems to us, have the eye of reason closed. We, therefore, shall postulate the existence of such a Supreme Power, and we shall also postulate the existence within us of a spiritual principle which thinks, feels, and acts. We shall regard the brain as its organ, as governed by physical law, and yet as acted on by the mind with which it is in close and mysterious connection; and we shall see that this physical organ is so formed that its forces and its substance may be available for the purposes of voluntary motion, and subject to the controlling influence of the mind, with which it is in immediate connection.

In the preceding chapter we showed how free force is obtained by the decomposition of water by means of zinc and copper plates, and how we can make this force available for purposes of heat, light, and mechanical, moving power.

It is very well known that power or force is also obtained by the decomposition of vegetable tissues, as by the combustion of wood and coal. Our object is now to show that power or force is obtained in a not entirely different way, so far as

outwardly appears, namely, by the decomposition of the animal tissues.

The animal organism is a complex vital machine ; it does a great deal of work, and it shows its excellence by doing the work with far less loss of power than any artificial machine we are acquainted with. The animal machine is the scene of a constant process of building up and of pulling down of its tissues ; this is indeed the great characteristic of animal life. No work is ever done by man, or by any other animal, without a rateable sacrifice of its substance.

Animal work is of two kinds: there is first the involuntary work of the heart, of the brain, of the stomach, of the liver, and of all the other organs in discharging their functions, and maintaining the integrity and energy of the vital organism. Second, there is the voluntary work, as for instance of the brain when employed in thought, and in conducting locomotion through the instrumentality of the nerves, muscles, and bones.

Both these varieties of work, the voluntary and the involuntary, are obtained at the cost of the tissues, though in different ways. The whole subject is too wide for us to encounter here, and we shall therefore restrict ourselves to what concerns voluntary animal work—the source whence it is derived—and its immaterial and metaphysical nature.

Let us premise by saying, that as the tissues are decomposed for the purposes of work and power, so it is evident they must be constantly undergoing renewal and repair. This is accomplished by their incorporating into their substance the albuminous, fatty, and mineral principles contained in those substances which our animal tastes and cravings teach us to select as food. The question may well be asked, How is it that this principle which is impalpable and immaterial, and which we call force, can be obtained by the swallowing of such materials ? This question certainly involves much metaphysics ; let us in the mean time be content to illustrate the fact as best we can.

When a plant incorporates into its organism the elements of the mineral kingdom, it does so by an act of vital force stimulated by heat; when the mineral materials are thus converted into vegetable tissue, we may regard them as having been raised a stage above their natural mineral level.

Again, when the animal incorporates the *vegetable* principles, and by its vital force converts them into brain and nerves and muscles, this we may regard as raising the transformed mineral elements another stage. We may observe, however, in passing, that what they thus gain in chemical complexity they lose in stability, for the animal tissues are generally eminently unstable, and ready to be tumbled down to their former level on the application of a comparatively feeble force.

We may complete our illustration of the subject thus: a labourer exerts a certain amount of force in carrying stones up one storey of a building, this we may view as corresponding to the elevating of the mineral materials and incorporating them into vegetable tissues. Suppose, then, another labourer takes these stones and carries them up a second storey, say to the top of the wall of the house, and piles them up there in a complex and ingenious manner, forming beautiful but unstable structures, this may represent the elevation of the vegetable principles into the higher combinations maintained in animal organisms. Now, as the power employed in elevating the stones need not be lost, but may be recovered and utilized by causing them to descend to their former level, and in doing so to draw up a corresponding weight of heavy material to the position from which they have descended, in a somewhat similar manner do we, according to the received theory, obtain power by the decomposition of the animal tissues, and by throwing their materials back, as it were, to a lower state of chemical combination. By doing so it is found that we recover the free force which had been employed by nature in raising and incorporating them into the animal tissues.

If the vital force which incorporates these materials in the vegetable and animal organisms is represented as the labourer, and if the brain, nerves, and muscles are made to stand for the piles of stones, then the only question that remains is, what is the agent which casts down these piles, or in other words, decomposes or disintegrates, the brain and other tissues mentioned, and thus obtains power for the purposes of animal motion? There can be no doubt that the mind conducts this part of the process, and that it is in this and in all voluntary effort a prime agent. We believe it is the mind which not only directs the free force through the proper channels, but also with nice discrimination obtains it from the brain, in measure to suit the object required, whether that object be to produce melody by the skilled and light fingering of the pianoforte, or slowly and laboriously to heave up a heavy anchor.

The importance of the brain for the purposes of thought has never been disputed, but its importance for the purposes of voluntary motion has not yet been fully recognized; and yet we have very strong evidence that it is at once a prime generator and director of animal power in voluntary motion.

Till very recently it has been held, that as the muscles were the organs of motion, so they were the sole sources of physical power in voluntary motion, and that this power was obtained by their decomposition. The amount of urea excreted and believed to be derived from this disintegration, it was expected would afford us an exact criterion of the amount of work done. The results were not, however, found sufficiently correct to confirm this theory, and the impression has according been gaining ground that oleaginous, as well as nitrogenous materials, contribute to the genesis of animal power.

On purely theoretical grounds, one would be disposed to regard the brain as a great source of voluntary power.

As the office of the blood in the adult is to repair the waste of tissue and to remove the effete material produced by this waste, so we may estimate the importance of any organ by the

amount of blood with which it is supplied. It has been computed that the brain is supplied with five times the average amount of blood furnished to the rest of the body, weight for weight; we are therefore authorized to conclude that the brain is an organ which undergoes rapid and constant waste and renovation, and that there must be generated in it a proportionally large amount of free physical force for conducting animal action.

The peculiar chemical constitution of the brain makes it yield readily to decomposition, and thus fits it for its office. The brain is found after death to be the part of the body which soonest breaks up.

The brain, being the centre both of the sentient and motor nerves, and being thus the direct organ of the mind, it is natural to conclude that it is a chief source of animal power In confirmation of this, we have experience (as stated fully in chapter xl.) that the amount of physical work and of mental effort exerted in accomplishing it bear a constant relation to each other. We believe then that the mind by a voluntary effort has the power of producing decomposition of the brain and motor nerves, and thereby liberating the free transmissible power employed in producing contraction of the muscles. How much of the power employed in muscular action is due to the brain, and how much to the decomposition of the muscles, has not yet been ascertained.

It has been much the habit of physiologists to consider that the whole animal power is derived from the muscles, and that the mind and the brain merely supply the spark which excites the muscular action, much as by a spark one might explode a whole magazine of gunpowder. We must observe, however, that the cases are not in any respect analogous. During physical exertion the mind's voluntary act is not one of mere command, but is a state or condition of sustained action. And we know that in dealing with physical difficulties the mind must be equal to the occasion, or its command will be ineffectual. Its act is, therefore, not that of a general

who with equal ease can order the march of a party, or the advance of an army; it rather suggests the efforts of a Ducrow or a Blondin. The mind feels that in every operation its success depends on the skill, and power, and judgment, with which it conducts its part of the performance.[1]

[1] It is known that cerebral power is evoked, but it is not exactly known how it and nerve power act, and are propagated through the motor nerves.

Nerve force is evolved in various ways. Either by the application of a physical stimulant, *i.e.* by an agent which in some way or other prompts or produces action. The nerves are thus acted on when we touch or press them, when we prick or cut them, when we apply any acrid or stimulating substance to them, or when we act on them by electricity. When we cut or pinch the excised end of a nerve, this mechanical interference causes the nerve molecules to discharge free nerve power, and an action passes, in a way not yet determined, through the nerve, and reaches the muscle which is thereby caused to contract.

Secondly. Free cerebral force, under the exercise of volition, also acts on the motor nerves. Volition may be supposed to produce chemical action or disturbance at the end of the nerve next the brain, and the free force there liberated may then act in a corresponding manner on the molecules immediately beyond; and so from point to point the molecular disturbance may, with great rapidity, be propagated along the nerve.

Third. We may simply conceive the cerebral force to be propagated along the nerve, from molecule to molecule, by its producing this chemical disturbance; or we may conceive it transmitted much in the way that a galvanic current is sent through a conductor. Or, fourthly, these two methods may be conjoined. The result of the experiment on an excised nerve, which shows us that the amount of muscular contraction is dependent on the length of the portion of the nerve artificially stimulated, would seem to favour the view that cerebral force is not only transmitted through the nerves, but that force is also generated in them throughout their entire length, as also in the spinal cord and other nerve centres. The contribution of the nerves, however, when we consider their trifling mass, can only be held to be a partial and temporary contribution, suited for immediate use. The great and steady supply must come from the brain, whose energy of action is evinced by its mass, and by the extraordinary flow of blood which is constantly being propelled through it.

CHAPTER XLIII.

CONCLUDING SURVEY.

THE writer now draws nigh the conclusion of a task which has exercised agreeably, and he hopes not unprofitably, a portion of the evening of a life which has been devoted mostly to very different pursuits, but which has always derived a higher enjoyment from those principles which are stamped on nature by the hand of the Omnipotent, than from the prosecution, however needful, of the details of mercantile or professional life. Providence, along with the special staple of a man's character, usually assigns a certain consciousness how it may be employed. That man, then, should esteem himself fortunate, who finds leisure towards the close of life to surrender himself to those pursuits which at once gratify his natural tastes, and which he may hope to render not altogether uninstructive to his fellow-men.

In the earlier chapters of this volume the object was first to direct the reader's attention to the phenomenon of inorganic matter with its peculiar properties; next to organized matter in connection with vegetable life; and, lastly, to organized matter in connection with consciousness. These are the three mysterious stages observed in nature.

The mineral elements first present themselves to us with their purely physical powers. We next see these elements compounded, not by man, but by nature's hand in a peculiar manner; and along with this arrangement, not only is the outward appearance changed, but an individuality is conferred The little pip, or nut, or bud, becomes a bramble-bush, an oak, a flower, and is capable of self-nourishment, growth, and

reproduction. Then, again, on the higher stage, in the animal, we see the self-same inscrutable elements combined in a manner slightly different; and in connection with these elements so put together, we discover not only life and organisation, but intelligence, voluntary motion, and self-government.

Matter, or physical substance, in these two last instances seems to man's apprehension to have got something superadded to its mere physical existence, which enables it to produce or show forth these remarkable results.

The belief in the existence of mind, or something essentially different from matter, would seem thus to be a natural, if not a necessary conception; for, by a law of our nature, when we cannot account for what we see in accordance with the known laws of physics, we feel compelled to postulate a non-physical cause. On the same principle, when we reflect on any of the known powers or energies of nature—say gravity—and seek an explanation, we go direct to the foundation cause, and postulate a non-physical cause to account for it. This seems necessary because science explains nothing, but merely shows the connection between one event and another, and enables us intelligibly to join them, as falling under the operation of certain laws; but the cause of these laws, *i.e.* the source of the power which makes them operative, science does not discover. It is on this account, as we have said, that we are compelled to go beyond the region of the visible, and to believe that an unseen spiritual existence underlies all physical phenomena. When turning this subject over in connection with organisation, the author in an early chapter threw out some speculations, more, however, to show that in our difficulties different positions may suggest themselves to the mind, than for the purpose of in that place commending any one specially to the reader's acceptance.

The wonderful complexity and perfectness of the organs of sense, which are framed for receiving impressions from terrestrial agencies, and from that majestic world-embracing element, whose measured movements give us the sensations

of light and heat, next engaged our attention. The adaptation of the organs of sense to the external agencies on the one hand, and to the requirements of the human intelligence on the other, is a subject serving very specially to interest the curious, and at the same time to illustrate the argument for design which carried such conviction to the minds of our fathers. Recent physical discoveries and speculations on the evolution of all natural productions in conformity with natural law, have in our day come much to the foreground, and to some minds have appeared so to have simplified the laws of creation as to rob even the most wonderful adaptations in organic life, and the most complex organs, of their mysteriousness, making what used to be considered Divine, now seem *only natural.* We have, in chapter vi., endeavoured to show the inconsistency of any theory which separates the natural from the Divine.

This is one of the errors of our day; but on the other side we see many religious men separating the Divine from the natural. A large class of men view all scientific theories, such as that to which we have alluded, with unreasonable aversion, evincing by their unmeasured opposition how strongly the old Gnostic errors still reign amongst us. The position which these persons assume is much as if there were a natural antagonism between the world's laws and the operations of Deity. They do not consider that there are different ways of regarding terrestrial phenomena, each of which if properly viewed may be equally reverent and pious. It is with difficulty such persons can be brought to apprehend that the world's phenomena are neither more nor less than the working out of the Creator's will in His own ways, whatever these ways may be. The power which in the animal organism draws the molecules into their places—which builds up the living organs—which gives the various structures their power of renovation and reproduction—and which, lastly, crowns them with self-consciousness, we may rest assured, whatever theory some of our *savans* may profess, will be held by the great majority of mankind

to be explicable only in connection with the operation, direct or indirect, of intelligence; and we doubt much whether any thoroughly developed mind will ever come to an opposite conclusion. Thinking men will naturally inquire, how without design should life appear at all? and if it did appear, why should it rise one step above the state exhibited by the lowest gelatinous dots of animated matter? What should suggest to insensible matter, or to such vitalized dots, legs, and arms, and eyes, and ears, and organs of smell, instincts, intelligence, reasoning powers, imagination, epic poems, thoughts of immortality, and of God. Why should dead matter burst out in such a rich profusion of shapes and conceptions? Can such things as these exist either as realities, or as conceptions, where there is no creative Intelligence to account for them?

It is one of the benefits of metaphysics that it almost inevitably leads us by quiet steps, to conclude the existence of an intelligent principle the cause of all things. This is, no doubt, a mysterious and very difficult thought, so mysterious, indeed, that it is next to impossible to think it at all, and yet so entirely necessary that it is altogether impossible for any thinking man to escape from it in any discoverable way.

In Part IV. we have given a brief sketch of the opinions and arguments of some of the leaders of philosophic thought, ancient and modern, and which we hope have served to bridge the interval between physics and metaphysics, and have led us from more ancient to more recent modes of inquiry.

Philosophy overlooks historical evidence as a ground of faith, not because it undervalues it, but because it seeks to build a self-evidencing structure out of the materials which are found within man's rational nature, and because it is an axiom with it that nothing which lies within the range of human criticism can be accepted unless it is homologated by reason, and that nothing can permanently hold its place as an article of faith which is contrary to man's judging faculty, properly exercised. Such being its position, how careful on

the one side should our theologians be not to overstate and overrefine questions which the reason can but ill understand; and how modest and reverential on the other hand should reason and philosophy be, knowing their own feebleness, not rashly to assail doctrines which, when properly understood, prove both wholesome and helpful to mankind. We live in transition times, and reason, like the atmosphere, is much disturbed. It seems almost as if, after centuries of dogmatic teaching, all were loose again; that we were afresh to be cast upon the establishing of first principles; and that the simplest articles of belief were to be confuted by the microscope. From this opaque, materialistic atmosphere, it is refreshing to look back from some of our crude modern theories of mind, even to remote pagan times, and to find there the clear realization of great truths now despised by many amongst us, but without which humanity cannot healthily exist in any age.

Part VI. is devoted to the subject of man's intellectual connection with the world by means of the senses. This branch has afforded the author much pleasure. His theory will, he hopes, be found not only suggestive, but exhaustive, by all who, believing in Deity, will reduce their theoretical belief to a practical scientific issue.

The nature of our sense knowledge, and the nature of the connection which the mind holds with the physical world, has long been a problem, and in the attempt to explain it, or to render it conceivable, nearly every variety of theory and speculation has been exhausted.

Dr. Reid and the founders of the Scottish school, while they did much good service by their inquiries into the powers of the human mind, systematically discouraged all inquiry which might bring us nearer a comprehension of the nature and cause of perception. They not only viewed perception as a mysterious phenomenon, towards the explanation of which the laws of nature could render no help, but they represented it in the light of a miracle which was altogether independent of physical laws. In direct opposition to this view, it appears

to the author that, as realists, believing in the world and in the efficiency of its laws, our duty in dealing with such a subject is to act on the assumption that *if we understand* the natural phenomena they will guide us to a solution of every difficulty of this kind. Our chief care, however, must be that the interpretation which we put upon the physical element is a correct interpretation. It is from failing to interpret the physical element aright, or rather from misinterpreting it, that much of the confusion of national and foreign writers has arisen. Our Scottish school, endeavouring from a purely mental stand-point to treat questions in which physics and psychology were necessarily blended, involved the subject in difficulties which are felt to the present day, but which disappear the moment we properly avail ourselves of the physical lamp.

In the contest with idealists, again, it seems to us that another error has been committed. Many writers on philosophy have blindly accepted Berkeley's position regarding the functions of the mind. And, starting from a false premiss, they have been unable to escape from the conclusion which it drew them into. Most writers have, like him, founded man's knowledge of the external world entirely on sensation, and have allowed themselves to be involved in the Berkeleyan net. They have neglected the most important of all our sources of knowledge, namely, that derived from our consciousness of possessing *mental* and *animal power*. This point we have fully treated in a chapter on Berkeley; and we therefore merely repeat that it is only by our bringing our active energies, mental and physical, into direct opposition with the physical energies of nature, that we acquire a knowledge of the world being anything more than a mirage or phantom of the imagination.

Had our writers more carefully considered the materials found in consciousness, and, instead of joining with the unthinking portion of mankind in assuming the existence of an unknown entity called matter, which is quite inadequate

to account for the operations of nature, and which has for centuries barred all attempts at a rational explanation of natural phenomena—had they, we say, examined a little more carefully, they would have discovered that the physical properties of which we are conscious, are but different modifications, not of matter, but of force. The apprehension of such a fact as this is most important to philosophy, for when we properly see and believe it, the world at once opens out to us, not as a meaningless mass of matter, but as a magnificent exhibition of power—a system or economy in which the Supreme Being, the source of power and being, by subjecting His absolute power—*qua* the physical world—to fixity and law, fulfils His purposes of sustaining living and conscious beings under the peculiar conditions which we observe in the physical world.

The writer has not expanded the theory into any details; this was quite unnecessary, for by merely assuming those mysterious elements, the chemical atoms, which no man can see or has seen, to be centres of force, and presenting physical substance as an aggregation of such dynamical atoms, the whole theory is complete, without deranging a single fact or principle of science.

To all who believe in a Supreme Mind the forces of nature, when rigorously and philosophically considered, must resolve themselves into the action of Divine power; and under such a belief, the theory of perception becomes at once simple and apparent, for our knowledge of the world is immediately seen to be the result of a connection between the Supreme Mind and the mind of the creature. Not that in our intercourse with the world we have any direct perception of the Infinite—that is impossible. Neither that there are any miraculous revelations—that is unnecessary. The position is this. The Infinite Being, in revealing the world to His creatures, while He shrouds His essential nature from them, reveals His power by suffering *our power* to come into direct connection and counterpoise with His, and also by making us the recipients

of those arbitrary signs which we call sensations, of which philosophers have written and thought so much, and which, though they give us so little that is specific or personal, we yet turn to so good account as media of knowledge.

Thus, though we see not the Infinite in His infinite attributes, yet in all the energies of nature we have an epiphany of His power, not only in the more striking phenomena, the conflagrations, and tempests, and collisions by sea and land, and all those inexorable exhibitions of power, amidst which living creatures are destined to tread, and where any act of ignorance, or any act of neglect, is followed by quick and certain ruin, but also in all the thousand milder physical influences which make life pleasant.

Surrounded with a variety of pleasures and pains, facilities and obstructions, man and all other living beings are destined to struggle forward to some goal, and, should their strength or their wisdom or their perseverance prove insufficient, they sink from the physical scene. This is more than a theory, it is the law of life upon our planet. It is only by continued effort that we hold our place in this world.

In connection with this picture of struggle and turmoil let us, however, on the other side carefully consider as a part of the arrangement, that the Author of our being has endowed man with intelligence by which he may be able not only to guide himself through such a scene, and escape from nature's dangerous energies, but may even turn the strongest and fiercest of them to profit. Man has accordingly made the winds and the waves, fire, electricity, and nearly every force in nature, subservient to his will. Let us only hope that amidst his constantly increasing acquaintance with physical powers and physical laws, he may, as the fruit of increased reverence and wisdom, come to see that the physical as well as the moral world, though they are amenable to two distinct codes, are yet, as governed by the same Lawgiver, alike entitled to his earnest and devout consideration.

In all worldly arrangements, notwithstanding the seeming

turmoil to which we have alluded, we have abundant evidence that, so far as man is concerned, they are indicative of design, though, as is to be expected when we rise to higher considerations, the plan becomes more complex and difficult to interpret. Certain points at least may be admitted without hesitation,—first, there is evidence that the senses are given to man, the highest creature, as they are to the humblest, not only for purposes of knowledge, but also for purposes of enjoyment. This is undeniable. But when considering this, another fact equally prominent comes into view. We observe that while physical enjoyment is a constant element in physical existence, and is equally essential to physical and moral health, there is nevertheless discoverable in man a principle which takes exception to the free and unqualified indulgence of those senses which are connected with the animal appetites. This apparent incongruity of the two natures in man, might with a speculator suggest the theory, either that man is a fallen angel, or that he is a raised brute—an animal in his physique, but one who, by the implanting of a higher principle, has been raised above the mere prosecution of animal indulgence to a recognition of his connection with the Being who formed him, and the hopes of a higher destiny.

The bodily wants must, however, be constantly and fully attended to ; and it is here that the difficulty arises ; for while the soulless lower creatures seem to have a license to indulge their appetites without restraint, man finds that all ill-regulated indulgence is highly injurious to him as a man ; and it is in the adjustment of this that the feeling of antagonism, to which we have alluded, takes its rise. In settling this controversy it must be received as an all-important axiom, that the laws of God are given us for our well-being in every respect, and not in any measure or degree for our injury or destruction. Keeping this truth before us, we next realize the fact that man is privileged by the gift of reason, and that this is given to direct him how he is to comport himself amidst these and all other difficulties. It is by its arbitrament

alone that he is to secure himself, on the one hand, against the debasement of his higher nature, and on the other hand, to protect himself from that tyranny of the principle, which is recognized as asceticism, and which is the dictate of a moral sense unenlightened by a knowledge of the requirements of his compound nature. When we reflect how many of the human race go down to ruin and debasement, it will be admitted that to effect the due adjustment must be far from an easy matter. It requires, in truth, a variety of rare qualities—the exercise of a well-regulated judgment, a resolute manhood, an enlightened moral sense, and a recognition of the never-to-be-forgotten rule, that in every case of doubt it is very much safer to stand some degrees up on the higher platform, than to descend any assignable measure on the downward side. Man can only steer safely and creditably through the peril-bound voyage of life, and attain a condition suiting him for the more serene life which is to follow, by a resolute and enlightened exercise of all his faculties, moral, intellectual, and religious.

The senses of sight and hearing afford us a pleasing confirmation of the position we have announced above, that in our connection with nature there is an evident provision, not only for our knowledge, but also for our enjoyment. These senses are entirely disconnected from appetite, and yet they strikingly minister to our æsthetic enjoyments. Who can observe the constituents of light, as they issue from a spangle of cut crystal in fanned-out rays of red, orange, yellow, blue, and violet, in their purity and beauty; or who can cast his eyes on the fields, the woods, the sky, the ocean, and reflect that all nature's tints are, by the constitution of our mind, and of our organs of sense, or shall we say, simply, by the ordinance of God, the results of certain rapid *motions* which are transmuted for our enjoyment into the glorious psychological phenomena of which we speak? Or when we are regaled by the effects of sound, and reflect that here again the harmony is but transmuted motion, or transmuted thrills of force, which our

perceptive and intelligent nature not only makes significant, but which our æsthetic nature drinks in as in a high degree elevating and Divine. Is it possible, we say, to reflect on phenomena so brought about, and fail to see that the world is purposely beautiful.

Again, let us note this as equally suggestive. If it is a law of the mind to transmute external movements into its own peculiar sensations, so it is no less one of the properties of the mind, after having so received things external, and transmuted them, to project them again outwards, and spread them over external nature in a mental garb. This is one of the means by which we are drawn, as it were, out of ourselves, and out of merely subjective indulgence, and made to bestow a large share of our sympathies even upon inanimate objects; for let us remember that while the forms and movements of nature are her own, the colours, the warmth, the fragrance, the sounds, which she seems to possess, *exist nowhere but in the mind;* but by this happy but compelled law of our nature to which we allude, we make external nature the reflection of our inward sensations.

This habit of projecting outwards what exists within, is indeed one of the great organic laws of the mind; and it is a law which has a much wider application than that which extends merely to the sensations. The poets have abundantly testified how fully it applies to all our moral sentiments passions, and emotions. Milton makes it the scornful boast of Satan that the mind is its own place, and in itself can make a heaven of hell, a hell of heaven.

Byron in a morbid, desponding tone, expresses the same psychological law:—

> "No more, oh! never more to me
> The freshness of the heart can fall like dew,
> Which out of all the lovely things we see
> Extracts emotions beautiful and new.
> Hived in our bosoms like the bag o' the bee,
> Think'st thou the honey from these objects grew?
> Oh! no, 'twas not in them, but in love's power,
> To double even the sweetness of a flower."

A man may form a thousand conceptions and imaginations which he may never have seen externally realized, but he can form no conception whatever of moral dignity or goodness, nor indeed of beauty of any kind, except he has these virtues and sentiments inherent, or at least periodically working in his own nature. The pure, the benevolent, the forgiving alone can know the Supreme Being as distinguished by these attributes ; the malignant and depraved conceive Him but as a demon. And in the same way do different types of men estimate the character and motives of their fellow-men. We can understand, we can believe in, no virtue in others which we have not experienced in our own breasts ; and as a mother, in whose heart the maternal instincts have been aroused, sees beauties and graces in every sound and movement of her child, so do we in a large degree stamp our own feelings and affections and characters upon our fellow-men, often indeed giving them credit for virtues which they but sparingly possess. Were it not for the operation of this law, how miserably meagre and profitless would this world be to us!

If all we obtained by the senses were only certain sensations more or less pleasing, or more or less painful or disagreeable ; if all we perceived were merely that external objects were hard and unyielding, or soft and pliable, and that they had certain colours and smells, that some gave us strength and others deprived us of it; if this meagre knowledge were all we gathered from physical objects, what would we have to attach us to the world, and to make it a field of such never-ending interest? The mind is the great creative power ; it is the living, ever-active principle given us, which transmutes, as we may say, the dust of the world into gold. It takes up the dry, lifeless, soulless materials of sense, and, bringing them into alliance with its own spiritual nature, endows even inanimate things with life and feeling, and converts arbitrary signs and symbols into the language of thought. The mere symbols it esteems of little moment in themselves ; it uses them as helps

to higher truths, it speculates on causes, it discovers laws, it is warmed with affections, it is charmed with the beautiful, it is elevated with hope, it lives in human sympathies, it anticipates the future.

Even viewing the mind in a cold, intellectual aspect, we are not to imagine that the simplest act of perception is a mere consciousness of sensation; such a notion might suit the materialist, who would have perception to be no more than an impression made on a receptive substance. Pure being, says Hegel, is pure nothing; in the same way pure sensation is pure unconsciousness, but there can be no such thing as pure sensation. An act of perceptive sensation embraces a variety of elements so numerous and subtle that it is only by much patient reflection and effort that we discover a few of them, so unobtrusively are they present. Thus, in the simple intuition of an object, or representative sensation, it is evident that the mind must have the power of abstracting the object from its surroundings; then it must distinguish its parts, their forms, sizes, colours, and relative positions, and make a synthesis of these, as parts of a one object, otherwise there is no object perceived or conceived. It must also recognize the object as one formerly known, or as now for the first time known. This again leads us to see that there can be no perception without a consciousness of our own self-existence, and our relation to the object, and the object's relation to us. With this is joined a consciousness of duration, the simultaneous duration of the self-conscious beholder and of the object beheld. Again, we cannot possibly perceive or conceive one object without the prior or simultaneous perception or conception of many other objects, for perception implies an act of judgment and comparison: the infant can have no conception of its mother or its nurse, unless it has also a conception of the other accompaniments—of itself, its crib, the pillow, the ceiling, the candle-light, and of many other things, stationary or moving, bright or dull, single or complex, and as such,

[1] "The World Dynamical." Edinburgh, 1868.

differing from, and contrastable with her, and with one another. Thus the simplest act of perception implies not only an intuitional sensation, but the exercise of many mental powers.

And if such is the case, we know that just in proportion to the extent of our knowledge and experience, is the thoroughness and extent of this faculty of perception. The learned perceive in a primrose, in a pebble, or in the colours of a beetle's wing, laws of growth, histories of our planet, and mysterious principles of physical action, to which the general eye is entirely blind. But the subject is too wide, and we must leave the reader to make his own reflections.

As our theory is founded on the general belief in the existence of a Spiritual Being of supreme wisdom, so we hold that the common belief, that the mind is also of the same spiritual essence, is a rational and indeed necessary inference.

Whether the human mind may act independent of physical or corporeal connection has been made a question. To attempt an argument on one side or on the other, must of course be vain, for we know nothing of thought or of any powers of the mind irrespective of its connection with organization. Physiologists say we have no evidence of thought existing when the brain does not act. This is undoubtedly the case; but such a fact is, of course, not sufficient proof that there is an absolute privation of thought. Even in health we are occasionally conscious of the mind having been for a time either entirely unconscious, or with the line of thought so faint that it left no trace. It is argued that in syncope the mind is dormant, because on recovery we have no remembrance of thought; but neither is this fact conclusive, for during trance or somnambulism the mind is frequently very actively engaged, as evinced by the words and performances of the patient, and yet when he awakes he has no remembrance of his thoughts and doings. Another theory, however, may be proposed. It seems to the writer possible that, when the physical element which accompanies all ordinary human thought

is lost, by the loss of cerebral action, we may be rendered merely unable to translate the thoughts of such a state into forms to suit the conditions of our normal consciousness. It is quite possible, we say, that thought, disconnected from brain action, may be essentially different from ordinary world thought, and if so, it is natural to believe that, on regaining our normal consciousness, we may not have the ability of recalling it and weaving it in with our ordinary thought. In support of this idea, we must remember to how great an extent the language and structure of thought in our present state of being is cast in the forms of our physical impressions and feelings. Even our most abstract conceptions are clothed in a mental language, derived from what, as physical beings, we have seen and felt. We may almost say that it must be so. It is believed that every act of thought is accompanied by an action of the cerebral substance; and it is matter of experience how much the brain becomes exhausted by continued mental application—not that we are from this to conclude that the movements of the brain are the cause of thought; it is more natural to conclude that the action of the brain merely gives qualitative expression to human thought, and makes it what it is, namely, a succession of concrete conceptions, clothed in feelings and sensations.

How it may be with the mind, when it has shuffled off the mortal coil, we of course can form no conception; but we may assume that when separated from all organic helps and trammels, the mind may awake only gradually to self-consciousness, by the entrance of truths and experiences invested in ideas and forms of thought altogether and essentially new to the mind, educated as ours has been amidst physical scenes and cerebral movements, so that almost as in fœtal life we shall have to grow to a power of blending former self-consciousness with what, from its novelty, we shall feel at its start to be almost a new birth and a new existence. If we can rest firm on the prospect of a future life, we may well allow questions of this kind regarding the nature of spiritual corporeity

to stand in abeyance, or we may be content to entertain them merely as an occasional speculation.

To conclude, let us remark in connection with this part of the subject, that in nature we observe many things which are exceedingly interesting, and which are at the same time entirely inexplicable. Take the instincts of animals as a case in point. The characteristics of animal instincts will be found to be, first, that they are essential, or at least of the highest importance, to the life of the animal or to the continuance of the species. Secondly, it will be found that they are equally trustworthy as useful. Then, again, as we have said, they are inexplicable, *i.e.* not acquired by experience; so entirely indeed is this the case, that it has become a phrase even with the learned, *Deus est animus brutarum.*

Perhaps the instincts of such animals as do not survive either to tend their offspring, or even to see them in life, are the most curious and instructive of all. The butterfly, as if inspired by a mysterious wisdom, just before its death deposits its eggs, not where we would expect, amidst the flowers from which it had extracted its own nourishment, but on the under side of the leaf of the currant-bush, or cabbage, the object being, in the first place, to protect them from sight, and in the second place, that the progeny, which the parent is destined never to see, may, when it emerges into caterpillar life, have an immediate supply of suitable food. Here there are neither promptings of experience nor any hereditary knowledge to direct the creature, for, as we have said, butterflies never see their offspring nor know their wants.

Man also possesses instincts which are adapted to his necessities, both as an animal and as a rational creature. The great instinct which distinguishes him from every other creature, is his belief in a state of existence, of which he has as yet no experience. We may well inquire how has this belief entered his mind? How has man been enabled to break through the bounds of the visible, and with all the hope-killing circumstances of death and corruption before him, to

indulge the anticipation of another and a brighter existence. This, as we have said, is man's crowning instinct; and the question may well present itself, Is this prophetic utterance a trustworthy utterance? All we can say in answer is, that to doubt the credibility of this instinct would be very much equivalent to disregarding the analogy of nature; for why should the instincts of the humblest creatures be so wonderfully truthful and unerring, and that of the most gifted of God's creatures be judged a principle implanted merely to mock and deceive him. This is an inconsistency from which the judgment and the moral nature of man alike recoil.

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